Design and Development of a Smart Hand Glove for Assistive Home Automation for Physically Disabled

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Abstract - The designing and development of a smart hand glove to facilitate home automation with the use of hand gestures by the physically disabled is an advanced system that aims to enable the physically challenged individuals to convey their basic needs using hand gestures. The smart hand glove is equipped with four flex sensors to detect finger movement and an MPU6050 accelerometer to detect the position and motion of the hand. The sensor readings are interpreted by the ESP32 microcontroller to determine the specific gestures and then generate a corresponding message via a speaker using a voice output module. The generated messages include “I need water,” “I need food,” “I need medicine,” and “I need help.” The same message is conveyed via an LCD monitor screen for clarity.

Furthermore, the smart hand glove uses Internet of Things connectivity technology through the ThingSpeak platform to communicate alert messages over Wi-Fi connection to remote locations using mobile applications. The system allows for controlling appliances such as lighting systems and electric fans via relays connected through a NodeMCU module.

Key Words: Smart Glove, Flex sensor, Patients, ESP32, Home Automation, Mobile Application

1.INTRODUCTION

Communication is one of the basic human requirements since it helps in communicating emotions, requirements, and emergency messages. Some patients who might have speech impairments, paralytic conditions, bedridden Ness, neurological conditions or those recovering from surgery become incapacitated in conveying their needs to others. As a result, these people entirely depend on the care provider to meet their needs. Communication breakdown causes distress among other problems since no timely attention is provided to patients whose condition requires prompt medical attention. Communication systems using call bells, writing boards, hand signals etc. do not provide sufficient means to facilitate this need effectively because the patients cannot use the traditional system efficiently. An intelligent, easy-to-use and reliable system of communication must be implemented to solve this problem.

Introduction to Assistive Home Automation through the use of Smart Hand Glove to facilitate Physically Disabled to convey their essential messages via simple finger movements. In this system, the primary components include a smart glove having 4 flex sensors and MPU6050 accelerometer inside it. These sensors are used to sense movement patterns of hands of the patient. The flex sensors detect the bending patterns in different fingers whereas MPU6050 detects the orientation and movement of hands. In this way, all the gesture movements are captured accurately which are then processed further in the system. For analysis of input pattern, the data is then sent to an ESP32 microcontroller. This controller analyses the input and compares the same with the pre-defined pattern stored in its memory. On matching, an action is performed which transforms gestures into vocal messages.

For prompt and accurate communication, the identified message is made audible using a voice playback module attached to a speaker. Messages like "I need water," "I need food," and "I need help" are recorded and stored in advance. As a result, there will be no need for a caregiver to decode the user’s messages since they can get them easily at once. Additionally, the message is shown visually on an LCD screen so that caregivers do not make any mistakes and are assured of the accuracy of received information. In case the environment is too noisy, the system is efficient in communicating due to its audiovisual output.

Moreover, the system includes the functionality of switching modes, enabling users not only to converse but also to control various appliances in the house. The process of switching from conversing to controlling is performed by doing some specific actions involving bending fingers and changing hand positions. When the system operates in controlling mode, predefined actions are required to turn ON and OFF the appliances, such as lights and fans. The message is sent using ThingSpeak, which is received by a NodeMCU unit. Then, it commands the relay units to turn ON and OFF the connected appliances.

2. LITERATURE SURVEY:

a. **H. Rekha et al. (2024) – Wearable Smart-Glove for Vocally Impaired Communication** Rekha et al. designed a wearable smart-glove based on MEMS that was capable of identifying gestures called hanok d using flex sensor and inertial measurement units including accelerometer. The system was capable of classifying the predefined gestures mapped onto specific communication commands and then converting them into voice outputs by utilizing text-to-speech technology. Moreover, the glove incorporated health monitoring functions such as body temperature and heart rate monitoring functions for enhancing its usability in assisted living environments.

b. **Vaishnav M. Sudhish et al. (2024) – Gesture Speak: Smart Glove for Inclusive Communication** In this study, Sudhish and his team have created Gesture Speak, which is a smart glove capable of recognizing hand gestures based on the detection of movements with the help of accelerometers and flex sensors. These gestures will be analysed with the help of microcontrollers like Raspberry Pi and Arduino Nano. Subsequently, these gestures will be translated to synthesized speech. This technology promotes inclusive communication by helping people with difficulty speaking or hearing communicate with others more effectively.

c. **Angshuman Khan et al. (2025) – IoT-Enabled Sensor Glove with Health Monitoring** Khan and colleagues described a glove-based solution for paralyzed patients using the Internet of Things that includes both gesture detection and health monitoring features. What makes this research special is that the authors managed to incorporate the functionality of vital sign measurement (SpO_2, heartrate, body temperature) sensors along with gesture recognition through flex sensors and MPU6050. Information from the glove is collected by Wi-Fi and sent to the cloud, thus making it suitable not only for communication but also safety purposes.

3. METHODOLOGY

The methodology behind the design of the above system will encompass the following elements: sensors, gestures, communication through IoT platform, and appliances control mechanism there Block Diagram Shown in **Fig -1**

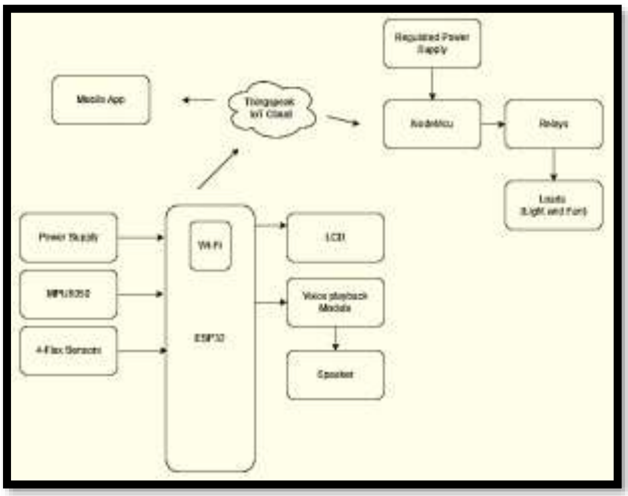

Fig -1: Block Diagram of the Circuit

3.1 Sensor Data Gathering

- Flex sensors are used for detecting angles of finger movement.
- MPU6050 is responsible for determining hand orientation.

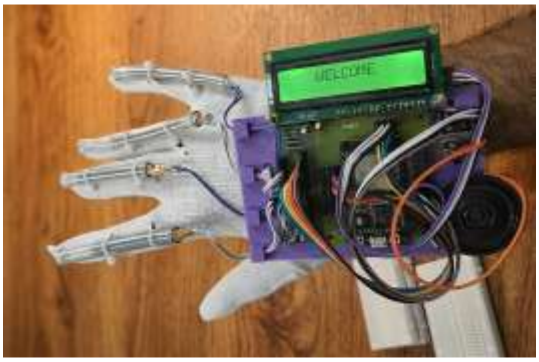

Fig -2: Smart Glove Unit

3.2 Signal processing and calibration

- Analog output signal of flex sensors is digitized using the ESP32's ADC.
- Threshold values determine whether the fingers are straight or bent.
- Orientation thresholds based on the accelerometer output. Shown in **Fig -2**.

3.3 Gesture pattern matching

- Specific combinations of finger bends and orientation patterns are preprogrammed into the ESP32 microcontroller.
- Pattern recognition algorithm matches incoming data to the predefined patterns.
- If there is a match, respective command is generated.

3.4 Output generation

There are four Modes in Gesture based assistive Communication and control electrical load.

Mode 1 – Load Control
Mode 2 – General Messages
Mode 3 – Request Messages
Mode 4 – Rest Position

3.4.1 Mode 4 (Rest Position)

No commands will not work, even fingers bend, because glove in rest position as Shown in **Fig -2**.

3.4.2 Mode 3 (Request Messages)

Fig -3: Mode 3 Output

when index finger bends and value of the change in resistance is more than 200 (limit set in code) than displayed and also speech comes from speaker as "I Need Food", like that Middle finger gives "I Need Water" Ring finger gives "I Need Medicine", The Little finger gives "I Need Help". These all are Requested Messages from patient to caregivers.

3.4.2 Mode 2 (General Messages)

when index finger bends and value of the change in resistance is more than 200 (limit set in code) than displayed and also speech comes from speaker as "Hello Welcome", like that Middle finger gives "Bye Byee", Ring finger gives "How are You" and The Little finger gives "Thank You" these all are general messages for good communication between patient and caregivers.

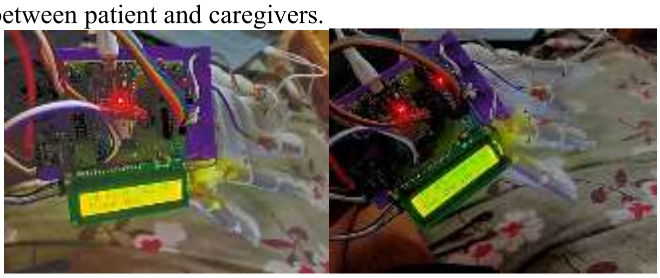

Fig -4: Mode 2 outputs

- Activation of the voice playback module according to the command generates audio output and message appears on the LCD screen as well shown in **Fig – 3,4**

3.5 Appliance Control mechanism

3.5.1 Mode 1 (Load Control)

Here, controlling light and fan by the gestures,

- When **Index finger** bends than Fan will Turn ON and message display and speech as **Turn ON Fan**. When **Middle finger** bends than Fan will Turn OFF and message display and speech as **Turn OFF fan**, shown in **Fig -5** respectively.

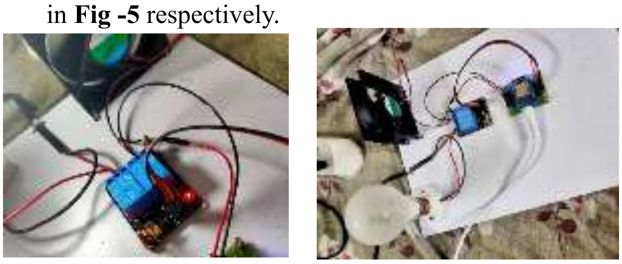

Fig -5: Mode 1 Fan Control

- When **Ring finger** bends than Light will Turn ON and message display and speech as **Turn ON Light**. When **Little finger** bends than Light will Turn OFF and message display and speech as **Turn OFF Light**, shown in **Fig -6** respectively.

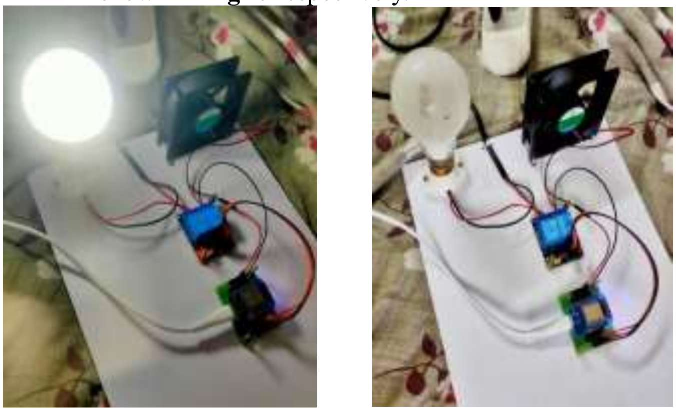

Fig -6: Mode 1 Lamp Control

- In the mode of appliances operation, data will be sent to ThingSpeak.
- The updated field data will be read by NodeMCU.
- Relay modules turn devices On or Off.

3.6 IoT Communication

- Collected data and alert messages are sent to ThingSpeak through Wi-Fi network
- Mobile application/dashboard will provide real-time notifications.

Fig -7: Mobile Application

Not only text displayed and speech. Also, the real time notification alert will come to app, which is developed in MIT APP INVENTORY. This app highlights the message. Caregiver can check in this app and go for it.

The Helmet Unit Consists ESP32, Flex Sensor, LCD, MPU6050, MP3Mini module and Speaker and their circuit Connection shown in below **Fig -8a**

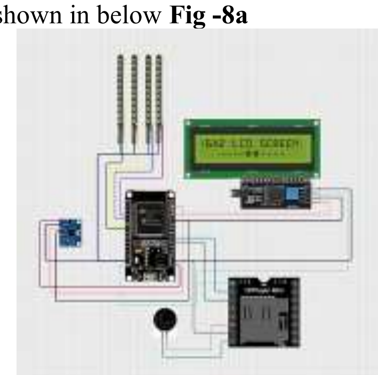

Fig -8 : Helmet Unit

The Load Control Unit consists ESP8266, Relay, CPU fan and Lamp and their connections shown in **Fig -8b**

Fig -8b: Helmet Unit

The overall circuit connection diagram given below

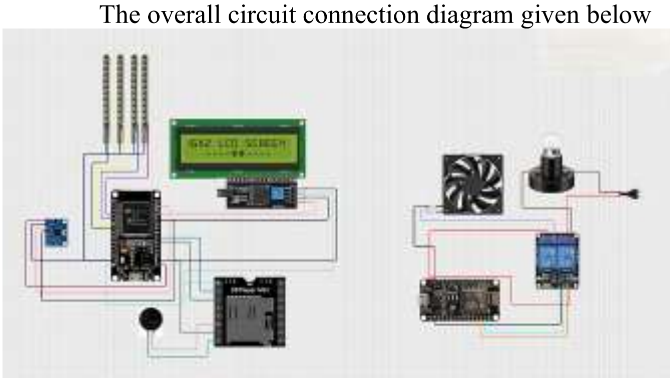

Fig -8c: Connection Diagram of Smart Glove and Home automation

4. CONCLUSIONS

Design and Development of a Smart Hand Glove for Assistive Home Automation for Physically Disabled provides an effective, affordable, and user-friendly solution for assistive communication and basic home automation. By integrating flex sensors and an MPU6050 accelerometer within a wearable glove, the system successfully converts simple hand gestures into meaningful voice messages and display outputs. The ESP32 microcontroller ensures efficient processing and quick response, while the voice module and LCD guarantee clear communication in both audio and visual forms.

The integration of IoT technology through ThingSpeak enhances the system by enabling remote monitoring and wireless control. Caregivers can receive real-time alerts through a mobile application, improving response time and patient safety. Additionally, the appliance control feature empowers patients with limited mobility to manage basic home devices independently. The system is portable, scalable, and cost-effective, making it suitable for hospitals, elderly care facilities, and home healthcare environments. Overall, the proposed solution significantly improves patient-caregiver communication, enhances independence, and contributes to the advancement of smart healthcare assistive technologies.

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