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Smart Wearable Glove For Enhanced Mobility And Communication

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Abstract: Communication is an essential human need, yet millions of individuals with speech and hearing disabilities encounter barriers in expressing themselves effectively. To overcome this challenge, we present a smart wearable glove designed to convert hand gestures into natural voice output. The system employs flex sensors embedded in the glove to capture finger bends, with signals processed by an Arduino ESP8266 microcontroller. These inputs are then translated into speech through an ISD1820 audio recording and playback module, amplified and delivered via a compact speaker. A 3.7V rechargeable battery with an integrated charging unit ensures portability and continuous use. Unlike earlier approaches that rely only on text or synthetic tones, this prototype provides real-time, clear audio communication, enhancing usability. The proposed solution delivers a low-cost, practical assistive device that bridges the communication gap for differently abled users, while also offering vital support for patients with paralysis or mobility restrictions.

Index Terms**–**Flex sensors, Arduino ESP8266, wearable assistive device, gesture-to-speech translation

I. INTRODUCTION

The World Health Organisation estimates that there are 285 million visually impaired individuals worldwide, of whom 246 million have limited vision and 39 million are blind. In the underdeveloped world, 90% of blind people reside. Deaf-dumb, blind people can communicate in different ways, according to their actual conditions and to the actual resources available to them.In both our daily lives and the daily activities of those with impairments, communication is essential. There are millions of deaf and dumb, blind, and physically crippled people in the world. They struggle with a number of things in their daily lives, such as communicating and operating household appliances. For those who are blind, using a cell phone to send SMS or make calls is extremely difficult or impossible. People with disabilities find it extremely difficult to move around and carry out their daily tasks.

Sign language is a vital means of communication for individuals who are deaf or mute. Instead of relying on spoken words, it makes use of **hand shapes, orientations, and body movements** combined with facial expressions to express ideas. Through these gestures, people can construct words and sentences that are clearly understood within the hearing-impaired community. In most sign languages, a single gesture can represent an entire word, making the exchange of information efficient and expressive. Within this context, a **gesture** refers to a specific motion of the hand formed in a predefined shape to convey meaning. For this project, the **flex sensor** is a key element, as it is capable of detecting the bending of fingers and translating those movements into signals that can be processed for sign language interpretation.

In sign language, each gesture represents a unique hand movement that forms a specific shape. Typically, entire words can be conveyed through these signs. The core element used in this study is the flex sensor, which alters its resistance according to the extent of bending applied to it.. Following with collection of the required parts, must connect them in accordance with the manual and, if necessary, programme the microcontroller to regulate the operation of the device.

The primary goal of the project proposal is to create an affordable system that, with the aid of smart gloves, can provide voice to the voiceless. It implies that the disabled person can communicate with others by using Smart Glove, which further contributes to closing the gap between the disabled person and the general public. This approach can help the deaf person overcome employment-related challenges. Therefore, an intelligent microcontroller-based system that makes use of sensors will be developed in the proposed work.

II. Literature Review

In their article "Smart Hand Gloves for Disabled People", Praful A. Landge, Parmeshwar P. More, Dhawal L. Patel, Harshal S. Tapase, and Prof. A. P. Bagade (2018) proposed a glove-based system with flex sensors attached to the fingers. The sensor's resistance changes with bending, allowing for the detection of finger movements. The device demonstrated how differences in sensor values based on bending angle could be properly mapped to gestures, allowing differently abled individuals to communicate.

Deekshitha R. U. and Mamatha V. published "Smart Glove: A Wearable Device for Disabled Persons" in the Journal of Emerging Technologies and Innovative Research. Their solution, GlovePi, was created with low-cost hardware and open-source components. The architecture consisted of three primary modules: the glove, the Raspberry Pi, and the MPR121 capacitive touch sensor module with an expansion board. An integrated Android application communicates with the Raspberry Pi server to display and vocal out the Malossi alphabet created by the deaf-blind user, providing a complete assistive solution.

In their article "Multipurpose Smart Glove for Deaf and Dumb People", Pravin Bhalghare, Vaibhav Chafle, Ameya Bhivgade, and Vaibhav Deokar (2020) introduced a system for recognising gestures by analysing finger bends. Each sensor bend generated distinct ADC values, which were saved and compared to assure precise gesture recognition. For accurate recognition, the system needed the user to hold each gesture for three seconds, and a table of average ADC values was kept for several users across different fingers (F1-F4, indicating little, ring, middle, and index).

Shreya Kumari Pandey, Ayush Bhan, Anandha Krishna Menon, and Chandra Shekhar Singh (2020) submitted "Smart Gloves with Health Monitoring and Security". Their solution combined several hardware and software pieces, with an Arduino Nano serving as the primary CPU. The Arduino processed user input from sensors and transformed it into audio and visual signals using application software. The design featured two major components: hardware and software, which ensured flawless motion translation while also adding capabilities for health and security monitoring.

In their paper "Smart Speaking Glove for Deaf and Dumb" Nirmal Kumar, P. A. Kasthurirngan, S. Musharaff, M. Mohan, M. Mohan Raj, M. Kathirvel, and P. Mohan presented a glove system that converted sign language into both voice and text displayed on an LCD. Predefined gestures were saved in the microcontroller, allowing the system to recognise them and create appropriate audio output. This enabled speech-impaired patients and others with physical limitations to successfully communicate their requirements using gesture-based interaction.

III. Methodology

We suggest Glove, a wearable gadget that serves as assistive technology for those with disabilities. The suggested Glove is an inexpensive solution that enables users to engage with others directly and independently of the outside world, doing away with the need for an interpreter or assistant.

The proposed system is divided into two main sections:

1. Section of the transmitter
2. The section for receivers

The suggested Smart Glove for the Disabled has two key components: the transmitter and the receiver.

1. Transmitter Section: The transmitter component is responsible for recognising and converting finger motions into digital signals. It includes the following blocks:

Flex Sensor: The flex sensor is attached to the glove's fingertips and detects bending movements. The sensor's resistance varies with the degree of bending, producing various electrical impulses that correspond to distinct gestures.

Microcontroller (ESP8266): The ESP8266 converts sensor signals into specified commands. It also functions as a communication hub, sending processed signals to the receiver portion.

Battery (3.7 V): The transmitter section is powered by a rechargeable lithium-ion battery, making it portable and easy to use.

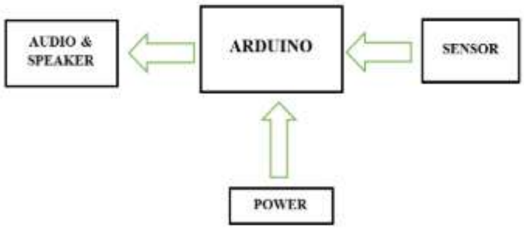

Fig 1: Block diagram of the disabled person's smart glove

2. Receiving Section: The sent impulses are transformed into useful audio output by the receiver unit. It is made up of the blocks listed below:

The Voice and Audio Recorder Module may save up to 10 seconds of previously recorded voice messages. The module responds to signals from the microcontroller by playing back the pertinent stored message. The Speaker Output then converts this recorded voice into audible speech, enabling effective and clear communication with others.

The proposed solution is a wearable glove design that integrates hardware and electronic components. The main processing unit is essentially an Arduino microprocessor, and flex sensors are used to record finger bending and interpret hand movements. A voice recorder/playback module stores and replays pre-recorded messages, while an amplifier module ensures that the audio output is sufficiently loud and clear. For portability and continuous usage, a charging module is incorporated, and the complete system is powered by a rechargeable battery. Finally, a tiny speaker that is tastefully incorporated into a pair of warm gloves provides the audio output, making the device simple to operate and practical for daily duties.

The popular Arduino ESP8266 microcontroller board, as shown in Fig.2, which includes the ESP8266 Wi-Fi module, is the central component of the building monitoring system. It is appropriate for a variety of IOT (Internet of Things) applications due to its many features and functionalities.Arduino is made to sense its surroundings and/or environment by using actuators to interact with its surroundings and sensors to receive input signals.

Fig 2: Arduino

A flex sensor, also called a bend sensor, as shown in Fig.3, is a kind of sensor that gauges how much an object or material is bending or flexing. Usually, it is composed of a thin ribbon or strip made of an elastic material that, when bent, changes its electrical resistance, like elastomer or plastic.

Fig 3: Flex sensor

The simplest method for adding voice recording (and playback) to the proposed model is to use the ISD1820 Recording Module Voice Board, as shown in Fig.4. The three push buttons on the module can be used to operate it directly, as can any microcontroller (such as an Arduino). On the board, a microphone is installed directly, and any 8-ohm speaker can be connected. Our recordings are kept safe even in the event of a power outage thanks to the ISD1820's non-volatile storage.

Fig 4: Voice recorder module

An electronic musical instrument, like a piano-style keyboard, that can be played by humans is called an audio module or sound shown in Fig.5. The most popular kind of MIDI controller, which is typically a musical keyboard, is required to operate sound modules. A sequencer is computer hardware or software that is used to record and replay control information for sound-generating hardware. This is another popular method of controlling a sound module. MIDI (Musical Instrument Digital Interface) is a standardised interface (PCB area and system cost savings) that is typically used to connect sound modules, controllers, and sequencers.

Fig 5:Amplifier module

Modular Charging Circuit Board Step-Up Boost Power Bank Charger 5V 1A DIY Lithium Battery Module 134N3P shown in Fig. 6. An on-board micro-USB input port and a USB type A female jack allow for 5V/1A power supply output and battery charging, respectively. With a 3.7V to 4.2V Li-ion battery, this super mini power bank main board is suitable.

Fig 6: Charging module

This lithium-ion rechargeable battery' as hown in Fig.7.Its superior capacity and discharge rate make it suitable for high drain applications. The first four digits of 18650 represent its size, which is 18 x 65 mm, and the fifth and final digit represents its shape, which is cylindrical. Generally speaking, these batteries can support 300–500 charge cycles.

Fig 7: Battery

Speakers are typically used to output audio, such as music. The transducers that transform electromagnetic waves into pleasing sound waves are the speakers. An increase in power to 10W will result in an SPL measurement of 100dB, or "twice the perceived loudness" in comparison to 1W. Hence, ten times as much power is required to produce the illusion of a doubling of volume.

Fig 8: Speaker

Fig 9: Hand Gloves

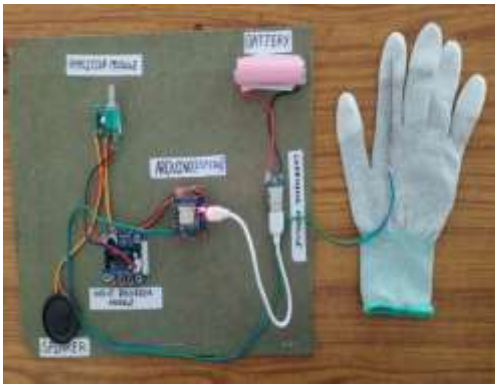

Fig 10: Prototype of Smart gloves

The prototype of Smart Glove as shown in Fig. 10 successfully translates hand motions into speech output, bridging the communication gap for differently abled people. The system's major sensing component is the flex sensor, which detects finger movements and sends appropriate signals to the ESP8266 microcontroller. The ESP8266 is programmed with custom circuitry to process sensor inputs and generate control signals for the output unit.

A speech recording and playback module that stores up to ten seconds of pre-recorded voice messages makes the produced prototype unique. A linked speaker plays the accompanying audio message when a gesture has been recognised and processed. Compared to systems that simply use text or artificial tones, this feature improves communication by producing clear voice output, which makes interactions feel more genuine.

During operation, the system showed dependable conversion into audible speech, accurate gesture recognition, and effective signal transmission. These results show that compared to many previous approaches documented in previous studies, the suggested Smart Glove provides a more useful, accessible, and user-friendly assistive solution.

IV. RESULT AND DISCUSSION

The recommended Smart Glove for the Disabled was successfully built and put into service using flex sensors, an ESP8266 microprocessor, and a speech playback module. We evaluated the glove's ability to recognise hand gestures and convert them into audible spoken orders. The ESP8266 processed the input signals accurately, the flex sensors reliably identified finger movements, and the voice module successfully saved and played back pre-recorded audio messages. When a motion was made and the corresponding speech output was audibly audible through the speaker, the expected functionality was validated.

The prototype's performance was evaluated based on four primary criteria: response speed, audio clarity and reliability, power consumption with mobility, and gesture detection accuracy. To determine the accuracy of gesture recognition, a number of preset movements were tested on different users; performance was determined by dividing the number of correctly identified gestures by the number of attempts. A timer was used to record the time delay between gesture completion and music playback, and the system consistently generated near real-time replies, ranging from a few milliseconds to one second. Participants were asked to rate the audio clarity and reliability on a five-point scale, with 1 representing poor audio quality and 5 representing exceptional, after ten seconds of pre-recorded messages were played via the speaker.

Compared to earlier studies, the developed Smart Glove provides a more practical and user-centric assistive technology by fusing gesture detection with real-time speech playback. Unlike earlier approaches that relied on text displays or a limited number of gesture-to-speech mappings, this prototype enhances usability in everyday interactions by enabling natural communication through configurable audio messages. The system's short latency, high recognition accuracy, and excellent audio output all attested to its dependability. Features like wireless connectivity with mobile apps, reduced hardware, and longer battery life could significantly enhance performance and user convenience in the future.

V. CONCLUSION

A practical and effective means of communication is provided by the proposed Smart Glove system for those who have vision, hearing, or speech problems. By translating motions into verbal output, it facilitates easy communication between the general population and individuals with impairments. It can also aid patients who have paralysis or other conditions that impair their ability to move around because it makes it easier for them to express what they need. This innovation not only increases independence but also fosters accessibility and social inclusion. All things considered, the study demonstrates that a wearable smart glove can be a reliable assistive technology that significantly improves people with impairments' ability to communicate.

VI. REFERENCE

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