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A Sensory Glove With a Limited Number of Sensors for Recognition of the Finger Alphabet of Polish Sign Language and with voice

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Abstract: This research presents a novel sensory glove designed for recognizing the finger alphabet of Polish Sign Language (PSL) using a minimal number of sensors while maintaining high classification accuracy. Traditional data glove designs typically incorporate multiple sensors across all fingers, prioritizing recognition accuracy at the expense of ergonomics, affordability, and practical usability.

Hand gesture is one of the method used in sign language for non-verbal communication. It is most commonly used by deaf & dumb people who have hearing or speech problems to communicate among themselves or with normal people. Various sign language systems has been developed by many makers around the world but they are neither flexible nor cost-effective for the end users

Key words: analog-to-digital converter (ADC), inertial measurement unit (IMU), MPEG Audio Layer 3(mp3)

I. INTRODUCTION

The report begins by explaining that hand gestures are a primary mode of communication for deaf and mute individuals. However, most normal people cannot understand sign language, creating a communication gap. To address this, the project proposes a sensory glove that translates hand gestures into speech and text. The system uses flex sensors and an Arduino Uno to detect gestures and produce corresponding audio and visual outputs. It also includes a health monitoring feature for disabled individuals. The system reportedly achieves 99.3% accuracy with a limited number of sensors, improving accessibility and user acceptance.

In the context of assistive technology, hand gesture is one of the methods used in sign language for non-verbal communication. It is most commonly used by deaf and dumb people who have hearing or speech problems to communicate among themselves or with normal people. Various sign language systems have been developed by many makers around the world, but they are neither flexible nor cost-effective for the end users. Sign language is the only way of communication for speech-impaired people, and it becomes difficult for normal people because they cannot understand sign language. To deal with this problem, the report implements a model that will help in reducing the communication gap between dumb-deaf people and society. Therefore, a speech device is suggested that will make it possible for mute people to convey their messages to normal people through hand gestures. A speaking system is incorporated with flex sensors whose resistance value changes according to the gestures specified by the user.

This gesture information is processed by the Arduino UNO microcontroller, and corresponding voice output is given through a speaker in the desired languages. In addition to this, healthcare monitoring for disabled people is also implemented. This configuration achieved 99.3 percent accuracy when combined with inertial data, representing a significant advancement over existing systems that require more sensors for comparable performance.

II. LITERATURE SURVEY

The literature survey begins with a paper titled "Smart Wearable Hand Device for Sign Language Interpretation System with Sensors Fusion," in which the authors used flex sensors and an Inertial Measurement Unit (IMU) to recognize sign symbols and produce voice output, with these components interfaced with a microcontroller programmed to obtain the

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corresponding output. Another paper developed a system for recognizing sign language using flex sensors and an accelerometer-based gesture recognition module, which provided audio output through a Text-to-Speech synthesizer and also included an SMS application through which a message could be sent to a mobile phone. A similar paper also developed a flex sensor-based gesture recognition module but provided only text and audio output without wireless messaging capabilities.

Another research work introduced a real-time two-way communication approach for hearing-impaired and dumb persons based on image processing, which included image acquisition, preprocessing, and feature extraction using MATLAB, generating outputs with a good amount of accuracy. Another study used an IMU module placed on the forearm to track hand movement in 3D space, along with an accelerometer and a GPS module for smart glove-based hand gesture recognition

Based on this literature survey, the report identifies the scope of the project as addressing the real-time issues faced by deaf, dumb, and disabled people who cannot move. The proposed system identifies hand gestures using flex sensors, with processing done using Arduino. The hardware scope includes five flex sensors attached to each finger, an Arduino Uno as the central processing unit, an HC-05 Bluetooth module for wireless data transmission, a DFPlayer Mini MP3 module for playing pre-recorded voice messages through a 3-watt speaker, a 16x2 LCD display for real-time visual feedback, and a 5000mAh USB power bank providing 4 to 6 hours of continuous portable operation.

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III. PROPOSED SYSTEM

The proposed system is a sensory glove designed with a limited number of sensors for recognition of the finger alphabet of Polish Sign Language and with voice output. The system consists of eight main components working together in an integrated manner. The power supply unit serves as the foundation, providing regulated electrical power to all components including the Arduino Uno, sensors, Wi-Fi module, and MP3 player, typically using batteries with voltage regulators to ensure stable 5V and 3.3V supplies for portable operation.

The flex sensors are the primary input devices that detect finger bending and hand gestures by changing their resistance proportionally to the angle of flexion, converting physical finger positions into analog electrical signals that are sent to the central controller.

The DFPlayer Mini MP3 module is a compact, low-cost module designed for easy integration into microcontroller-based projects, supporting audio playback from microSD cards up to 32GB and decoding common formats like MP3, WAV, and WMA. It features a built-in 3-watt mono amplifier for direct speaker connection,

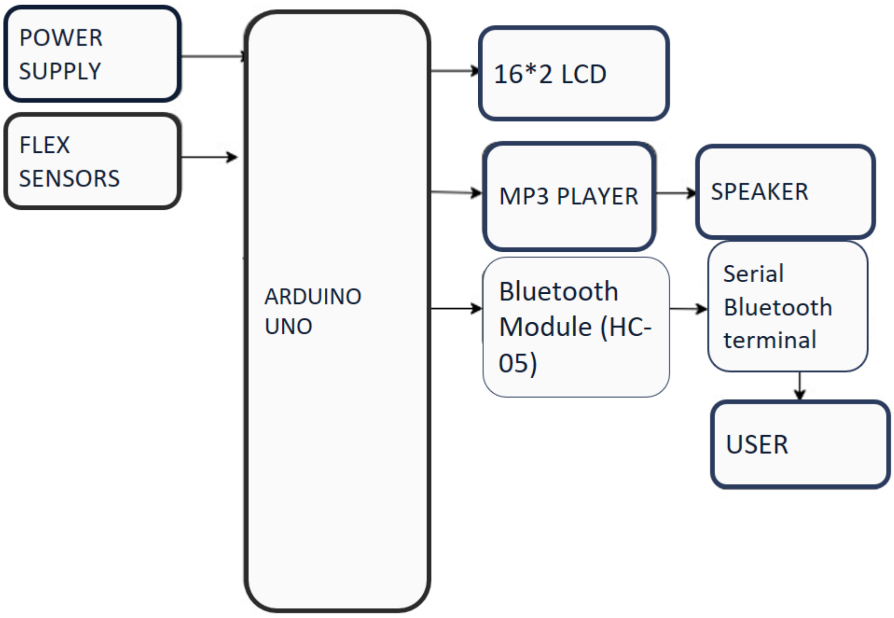

Fig. 1: Proposed System

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A display unit (such as an LCD or monitor) is integrated into the system to provide real-time information, including:

- Flex Sensors (5) – Detect finger bending.
- Arduino Uno – Central processing unit.
- HC-05 Bluetooth Module – Wireless data transmission.
- DFPlayer Mini MP3 Module – Plays pre-recorded voice messages.
- 16x2 LCD Display – Shows real-time text feedback.

The proposed system establishes a two-way communication between challenging and normal people, translating sign language into speech as well as text to voice for blind people, and in case of any emergency, a message will be sent to a friend or relative, and the other person can give a reply in text which will be displayed on screen.

IV. METHODOLOGY

The methodology of the proposed System is organized into the following steps:
A distributed network architecture was implemented with a Arduino uno server functioning as the central data collection poin
The Arduino-based glove transmitted sensor data via Bluetooth to a laptop running custom Arduino ide software
The HC-05 Bluetooth module was configured as slave device with device name GestureGlove and default PIN 1234
A visual prompt displayed on the monitor showed which letter to perform along with a reference image of the correct hand shape

Free TTS website is used to store the voice of certain finger movement and store in the memory card

➢ The system continuously monitors:

- Lcd display
- speaker

Five flex sensors are attached to each finger, and these sensors detect finger bending by changing their electrical resistance proportionally to the angle of flexion. When a user performs a hand gesture corresponding to the Polish Sign Language finger alphabet, the flex sensors convert the physical finger positions into analog electrical signals.

These analog signals are then sent to the Arduino Uno microcontroller, which serves as the central processing unit. The Arduino reads these analog signals using its built-in analog-to-digital converter (ADC), which provides 10 bits of resolution, allowing different values to be distinguished for each sensor.

V. PROPOSED SYSTEM HARDWARE RESULTS

The proposed system is a sensory glove designed with a limited number of sensors for recognition of the finger alphabet of Polish Sign Language and with voice output. The system consists of eight main components working together in an integrated manner. The power supply unit serves as the foundation, providing regulated electrical power to all components including the Arduino Uno, sensors, Wi-Fi module, and MP3 player, typically using batteries with voltage regulators to ensure stable 5V and 3.3V supplies for portable operation.

The flex sensors are the primary input devices that detect finger bending and hand gestures by changing their resistance proportionally to the angle of flexion, converting physical finger positions into analog electrical signals that are sent to the central controllerThe alert mechanism responded promptly by generating notifications when predefined threshold limits were exceeded, ensuring timely intervention.

The hardware prototype of the sensory glove system was successfully developed and tested, consisting of four main modules: flex sensors, an analog-to-digital converter, the Arduino controller which serves as the heart of the system, an LCD screen display, and a speaker for audio output. The flex sensors take the inputs of hand gestures and process them to the controller. The controller takes the input and gives the output in the form of audio and text. The system was tested for multiple hand gestures corresponding to different needs and phrases that a speech-impaired or disabled person might want to communicate.

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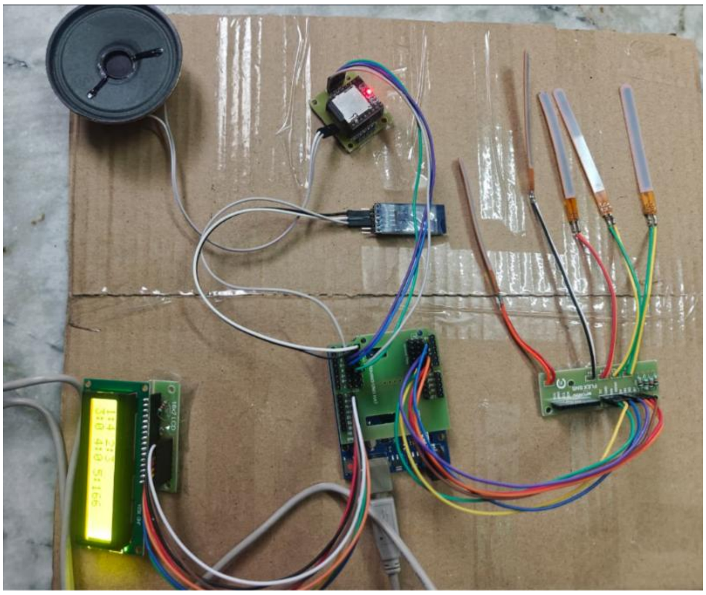

Fig. 2: Hardware Design

The overall hardware setup, including the Raspberry Pi, camera module, and sensors, functioned efficiently with smooth integration between components.

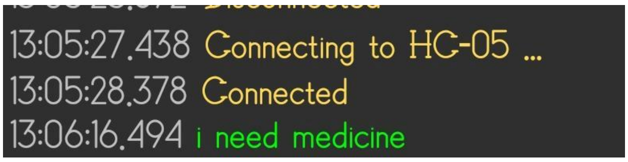

Fig. 3 : serial Bluetooth terminal app

Fig. 4: Output of an Image

The DFPlayer Mini MP3 module is a compact, low-cost module designed for easy integration into microcontroller-based projects, supporting audio playback from microSD cards up to 32GB and decoding common formats like MP3, WAV, and WMA. It features a built-in 3-watt mono amplifier for direct speaker connection,

The prototype successfully demonstrates:
Thumb gesture → "I NEED MEDICINE"
Index gesture → "I NEED WATER"
Middle gesture → "I NEED TO GO OUT"
Ring gesture → "I NEED TO WATCH TV"
Pinky gesture → "I NEED FOOD"

Each gesture is displayed on the LCD and played as audio via the speaker. The system is lightweight, portable, and provides two-way communication.

V. CONCLUSION

Every normal human being sees, listens, and reacts to their surroundings, but there are some unlucky individuals who do not have this important blessing. Such individuals, mainly deaf and dumb, depend on communication via sign

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language to interact with others. Deaf and dumb people communicate with common people throughout the world using hand gestures, but common people face difficulty in understanding gesture language. To overcome these real-time issues, a system has been developed.

The proposed system identifies a gesture using flex sensors, and processing of the identified gesture is done on the Arduino Uno microcontroller. Audio corresponding to each processed gesture is the final output, and text is also provided on the LCD screen. Simultaneously, speech-to-text functionality is also implemented. In emergency situations, a message will automatically be sent to their relatives or friends when an emergency gesture is made. The important key factor of this project is to facilitate these people from this risk factor and to make them more confident to manage their situations by themselves. This is a user-friendly, cost-effective system that reduces the communication gap between dumb,deaf,and disabled people with ordinary people.

This project is mainly useful for two-way communication between challenging and normal people. The device is used to translate sign language into speech as well as text to voice for blind people, and in case of any emergency, a message will be sent to a friend or relative, and the other person can give a reply in text which will be displayed on screen.

The main advantage of this project is that it can be carried away easily as it has less weight. This project will be beneficial to both challenging as well as normal people.

Future Scope:
The technology implemented in this project can also work in different languages with appropriate modifications. There may be more chances of increasing accuracy beyond the current 99.3 percent through further optimization of the machine learning models and sensor configurations. Increasing the number of gestures beyond the current eight can also be done with a good amount of accuracy, potentially covering the full Polish Sign Language alphabet and expanding into common phrases and sentences.

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