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Smart glove for hand gesture recognition

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ABSTRACT

Human beings have a natural ability to see, listen and interact with their external world. Unfortunately, there are some people who are differently abled and do not have the ability to use their senses to the best extent possible. Such people depend on other means of communication like sign language. This presents a major roadblock for people in the hearing and speech impairment communities when they try to engage in interaction with others who are unfamiliar with the sign language, especially in their educational, social and professional environments. Therefore, it is necessary to have a gesture recognition or sign language detection system to bridge this communication gap. The main aim of the proposed system is to develop a smart glove for real-time gesture recognition using IoT. A mobile application is used as an interface to convert gestures into speech or voice output.

Keywords— *Flex, IMU, Bluetooth TTS, DOF*

1. INTRODUCTION

In 2017, ISLRTC (Indian Sign Language Research and Training Centre) estimated that there are 386 deaf and dumb schools in India. All these schools are divided into separate zones based on their location [1].

Table 1: Zone division of disabled people

Zone	Schools
North zone	42
Northeast zone	21
East zone	44
West zone	129
Central zone	16
South zone	134

This signifies the number of people who cannot speak and listen like the common people. It is quite difficult for common people to communicate with the disabled person as they cannot understand their language. To overcome this problem we need a device to identify their gestures. This paper explains about a smart glove which deals in the field Of IOT (Internet of Things). It is a conceptt that describes the idea of physical objects being connected to the internet with the help of an IP Address and being able to identify themselves to other devices. Where devices and gadgets with built-in sensors are connected to the internet using an IOT platform, which computes and integrates data from the different devices and applies analytic to output the most valuable information. With IOT we can avoid human-to-human and human-to-computer interaction [2]. By using this glove we can identify the gestures and convert it into text which can be given out as speech through a mobile application. This product is compatible and easy to use. Such a device would have a large scope for the application given the number of schools dedicated to such differently abled people. It would open a lot of opportunities for them to lead a regular life.

2. RELATED WORK

There are various approaches to sign language detection like - Data glove approach, Vision-based approach and Virtual button approach. Previously few attempts were made to identify the gestures using various other methods. There are drawbacks like accuracy, feasibility and portability while using these techniques like:

- Using the CMOS camera,
- Leaf Switches based glove,
- Copperplate based glove,
- Using image processing technique,
- Flex sensor based glove.

2.1 Using the CMOS camera

CMOS camera accomplishes the task of capturing light and converting it into electrical signals. The CMOS camera is

pre-owned for the transmission of image data through the medium of the UART serial port. UART is for the conversions of serial to parallel on data received from a CMOS camera and the conversion of parallel to serial is done on data received from the CPU. Hand intimations were detected by CMOS camera using the following:
Step 1: Capturing the image of the gesture,
Step 2: Edge detection of that image,
Step 3: Peak detection of that image

Disadvantages: High latency, Expensive, High propagation delays, Low noise margins, 50kb of memory is occupied by each image [3].

2.2 Leaf switches based glove

These are like ordinary switches however these are outlined such that when weight is connected to the switch, the two finishes come into contact and the switch will be shut. These leaf switches are set on the fingers of the glove with the end goal that the two terminals of the switch come into contact when the finger is bowed.

Under normal condition, when the finger is straight, the supply voltage 5V will pass through the MC input. But when the finger is bent, the switch will be closed and the supply voltage will be drained through the ground and a voltage of 0V reaches the MC input indicating that the finger is closed.

Disadvantages: After elongate usage, the switch instead of being open when the finger is straight, it will be closed resulting in improper transmission of gesture [4].

2.3 Copper plate based glove

This glove can be made using small metal strips that are fixed on the five fingers of the glove as shown below. A copper plate is fixed on the palm as ground. It is better to use a ground plate instead of individual metal strips is because the contact area for ground will be more facilitating easy identification of finger position. The copper strips indicate a voltage level of logic 1 in the rest position. But when they come in contact with the ground plate, the voltage associated with them is drained and they indicate a voltage level of logic 0. Thus necessary gestures are formed.

Disadvantages: The use of copper plate makes the glove hulking which makes it unsuitable to use it for a long time [4].

2.4 Using image processing technique

In this approach, the gestures are captured by using a camera. Images are used as gestures data captured by the camera. Distinct algorithms are used to analyse this image for recognizing the meaning of each particular gesture. A sequence of hand gestures is created by the corresponding key gesture frames from the extracted information.

Disadvantages: Complex computational algorithms are required for detecting the gestures. This approach also needs a proper background and lighting condition.

2.5 Flex sensor based glove

Flex means ‘bend’ or ‘curve’. Sensor invokes to a transducer which converts physical energy to electrical energy. Flex Sensor is a resistive sensor which changes its resistance as per the change in bend or curvature of it into an analog voltage. This is a haptic technique which consists of using flex sensors to take in physical values for processing [3].

Advantages: High level of reliability, consistency, harsh temperature resistance, Variety of flexible or stationary surfaces for mounting, an Infinite number of resistance possibilities and bend ratios.

This prototype is discussed below using one of the recent technology.

3. HARDWARE COMPONENTS AND PROPOSED WORK

The functionality of each device used for this smart glove are mentioned below:

3.1 Flex sensor

Flex Sensor also is known as a bend sensor or variable resistance sensor where the values vary depending upon the bend. It is used to convert physical energy into electrical energy. As per the bend, the flex sensor changes its resistance into analog signals. As more the sensor bends, more resistance generates. It is based on the resistive carbon elements. The flex sensor consists of a thin flexible substrate when the substrate is bent, the sensor produces a resistance output correlated to the bend radius [6].

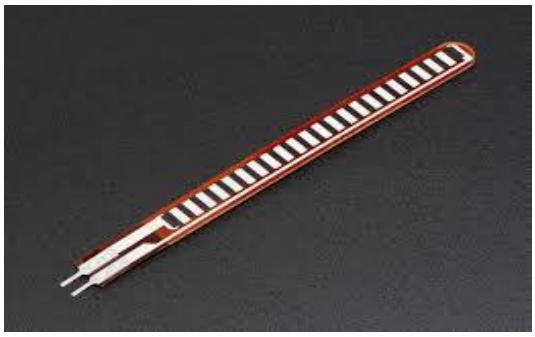

Fig. 1: Flex sensor

3.2 IMU (Inertial Measuring Unit)

Fig. 2: IMU

Inertial Measurement Unit (IMU) is a device which measures linear and angular motion usually with a triad of gyroscopes and triad of the accelerometer. The MPU6050 is an accelerometer and gyroscope sensor at the same time. It gives the pitch, yaw, roll values with respect to x,y and z directions.

The MPU6050 has a3-axis accelerometer and a 3-axis gyroscope in a single breakout board. The sensor is based on MEMS (Micro Electro Mechanical Systems) technology and uses the I2C-bus to interface with the Arduino or any other prototyping board.

3.3 HC-05 Bluetooth module

HC-05 is a Bluetooth module, designed for wireless communication. It uses serial communication to communicate with devices. It communicates with the microcontroller using a serial port (USART). For data transmission from the

microcontroller to the smartphone, a Bluetooth module is used. It works with a voltage range of 3.3V-5V. The smartphone requires Bluetooth terminal application for transmitting and receiving data between the devices. The Bluetooth module is transmitting at a 9600 baud rate [5].

Fig. 3: HC-05 Bluetooth module

3.4 Arduino UNO

The Arduino UNO is an open-source microcontroller board based on the Microchip ATmega328P microcontroller and developed by Arduino.cc. The board is equipped with sets of digital and analogue input/output (I/O) pins that may be interfaced to various expansion boards (shields) and other circuits. The board has 14 digital pins, 6 analogue pins, and programmable with the Arduino IDE (Integrated Development Environment) via a type B USB cable. It uses 5V power supply [7].

Fig. 4: Arduino UNO

3.5 Working

The glove is encased with five flex sensors to identify the finger movements, an Inertial Measuring Unit (IMU) is used to identify the movements in 3-D space and a Bluetooth device to transmit data to other Bluetooth connectivity devices over a short range. The area of focus is to identify the gestures made by a single hand. Arduino is a microcontroller used as the processing unit where all the devices are connected to it. When the gestures are made a range of values are obtained from the flex sensor and the IMU is used to identify the gestures or finger positions in a three-dimensional area. These range of values combined together represent or identify a gesture.These and the text format of the gesture is sent to the external device, the external device gives the voice output of the text. Here the external device is the mobile phone which has a Bluetooth TTS app installed in it for text to speech conversion to give the voice output.

Flex sensors connected to glove gives a range of values for different bends in the finger. Each finger is indicated with different notations like F0, F1, F2, F3, and F4 where F0 indicates thumb finger, F1 indicates index finger, F2 indicates middle finger, F3 indicates ring finger, and F4 indicates little finger. IMU recognizes the hand movement in 3-D space which gives values in x, y, z-axis. The gestures are recognized when the hand is in the y-axis (90 degrees) and led blinks when the hand is in exact 90-degree position which means the gestures are being identified. All these flex sensors and IMU are connected to the Arduino. Once the Arduino is initiated it takes the values from the Flex sensor and the IMU. After reading the values for each finger position the program searches a match of values in the database and if any match is found then it sends the data to the Bluetooth TTS app using the Bluetooth device, it gives the voice output. After a certain delay, the next values are obtained and the process continues.

4. RESULTS

In this prototype, the user forms a gesture and holds it for a few milliseconds to recognize the gesture.

Table 2: Range of values for each finger

Finger	Values
Thumb finger	>=970 &&<=985
Index finger	>=710 &&<=735
Middle finger	>=986 &&<=995
Ring finger	>=900 &&<=920
Little finger	>=760 &&>=780

For each bent in the finger, a different range of values is obtained. The IMU is used to identify the hand position and the angular movement in the wrist. The output is obtained only when the hand is in 90˚ position. These values identify the respective gesture and the voice output is given through the mobile application. Using these IMU and flex values gestures are identified.

5. CONCLUSION

A disabled person uses sign language for communication with another person. Conversion of sign language into text and speech is done so that communication is not limited between them. Utilizing smart gloves for communication, the barrier between two different communities is eliminated. Using smart gloves disabled person can also grow in their career and makes the nation grow as a percentage of the disabled person are millions in count as of now. Thus our glove which is being built with sensors that cost less, it is also not very costly and also has been prevented by any hazards caused by the sensors to the users.

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