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Development of Smart Glove for Deaf-mute People

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Abstract

This paper illustrates a Smart glove used to bridge the between the speech impaired and normal people in their day-to-day life. Nearly 70 million people are deaf by birth and 230 million people are hearing impaired or speechless because of the conditions such as autism or stroke. To overcome this situation, a research has been started, which uses flex sensors and accelerometer to read the gesture, Arduino UNO to process the input and a web UI to display the text output.

Keywords— Flex sensor, Autism, Deaf-mute, Sign language, Orientation of hand

I. INTRODUCTION

Major difficulties faced by hearing and speech impaired people are listed and analyzed to give better solution to overcome this problem. In this world communication is the most important tool to express one's ideas and thoughts. Expressing one's ideas or thoughts reveals about their intelligence and creative thinking. But the problem is that not all people can communicate to each other. There are some people who has some serious problem in speaking, hearing or perceiving things. These people always suffer a lot, and this defect makes them feel isolated from the normal people that cause some mental depression. As this the 21st Century, technology can provide a better solution for all kind of problem. Similarly, there is a solution to solve this problem and make those people merge with the normal world and do their routines. Specifically for hearing impaired people sign language is the only way of communication with external world. Sign languages are languages that use visual modality or hand gestures to denote the meaning of particular words as shown in Fig. 1.

Fig.1. ASL representation for alphabets and numerals

[Source: https://in.pinterest.com/pin/361695413796118607/]

There is a standard sign language for speech and hearing-impaired people are available which is used worldwide. Standard sign languages were followed all over the world because it would be easy if every country follows the same sign language and avoids a clash of various country's sign language. It uses hand gestures to represent a letter or a word. Hand gestures can be expressed in two different ways:

1) Static Gesture

2) Dynamic Gesture

In static gesture, gestures do not change, or it do not have any sequential order for its representation. In dynamic gesture, certain sequential order must be followed to get the information.

II. RELATED WORK

Few other works have been done in the relevant field.

Mathavan Suresh Anand et al. [2] explained the effective way for hand gesture recognition system. This hand gesture recognition system has many applications like sign language analysis, medical training, and virtual prototyping. The working of this hand gesture recognition system has three modules: Pre-processing, Feature Extraction and Classification. In the pre-processing stage, hand gesture is captured and noises in the frame is removed. Then, the important feature in the frame is extracted using Discrete Wavelet transform technique for the better and accurate classification. A simple KNN classifier is proposed to be used for sign recognition based on the extracted DWT features. The framework is mainly used for extracting features and classification. Finally, the Classifier is used to recognize the sign language.

Walid K A Hasan and Nadia Naji Gabeal [5] proposed a solution where the hardware components are used to identify the sign language to get precise output. The Microcontroller used is Arduino UNO. To get the orientation and positions of fingers, flex sensors are integrated with gloves and Arduino. Based on the data from the flex sensors, Arduino can classify the sign and convert it to either text or speech. Along with the flex sensor, accelerometer is used to identify the tilt angle of hand for classification. The controller uses the data collected by the two flex sensors to send commands according to the gestures. These sensors are attached to ADXL335 which is a glove that has a built in gesture recognition system. Using hardware for sign recognition system can avoid errors in classification and give the better result.

Nakul Nagpal et al. [1] proposed a theoretical solution to develop a communication aid for deaf and dumb to interact with normal people. A way of representing the gesture is of two types: Static and Dynamic. In static, gestures do not change, or it does not have any sequential order but in dynamic where the sequential order must follow to extract the information. Alphabets are best examples of Static gestures and Actions, or representation of activity is the example of Dynamic gesture. The proposed solution covers both the static and dynamic gestures for sign language recognition. Various sensors like accelerometer, electromyographic(SEMG), piezoresistive sensors are used to measure the hand gesture, orientation, and movement for analyse of dynamic gestures.

Mandeep Kaur Ahuja and Amardeep Singh [4] explained about the importance of hand gesture and its wide range of application. Hand recognition system not only helps the physically challenged but also in human computer interaction, robotics, sign language recognition etc. Various approach has been studied for hand gesture recognition. Skin colour-based approach, thresholding approach and template matching are some of the effective ways for hand gesture recognition. Initially, hand is segmented from the background and template-based technique is developed using principal component analysis to recognize the hand gestures more accurately.

Ashish S. Nikam and Aarti G. Ambekar [3] explained the various applications and benefits of hand gesture recognition system. In Non-Verbal Communication, Hand gestures play a major role in day-to-day life. The hand gestures are recognized based on the detection of some important features like orientation of hand, finger status, positions of thumb finger. Some Advanced computer vision techniques are implemented for segmentation and feature extraction.

P. Mohan et al. [6] explained that smart gloves help people with limited mobility to communicate with others. They can also convert a person's hand gesture into a pre-recorded voice. They can also

control a home appliance which helps a person to live independently. In present system, there is no way to announce the thoughts of physically challenged individuals. Instead, it uses sign language to communicate with the deaf & dump peoples. In this system, they proposed a way to convert sign language to voice. It also displays text in LCD monitor. The gesture recognition circuit is designed to generate a customized gesture for everyone.

Ajit Manware et al. [7] proposed a system in which each sign is detected by bending the fingers of the hand in a precise order and at a specific angle. The microcontroller receives the sensor data provided by each of the flex sensors. To recognize a certain alphabet, distinct sensor values are applied to different movements. Once an alphabet has been discovered, the bluetooth module sends it to an android application on a phone with bluetooth enabled. The android program will translate the alphabet to speech and show it on the screen, with the selected word spoken out loud.

III. EXISTING SYSTEM

In existing system, there is no circuit to announce the thoughts of physically challenged peoples. And gesture-based papers or circuits are not available in markets. In olden days it is sign language, it cannot be understood by all the people for communication. There after a circuit is developed to mimic predetermined postures and match them with deaf & dump peoples sign language.

IV. METHODOLOGY

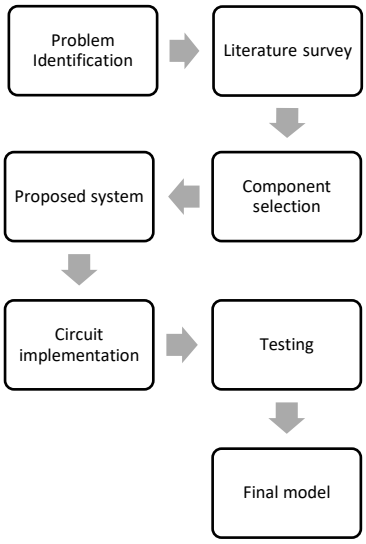

Fig.2. Methodology

The methodology for this project is shown in Fig 1 and it starts with finding the problem and analyzing the main cause of the problem and listing out the chain of actions related to this which affects in a direct or indirect way. The final thing in the problem identification is the root cause which is the uncertainty in where to look for the workers. Since the real problem and its cause is known. The next thing is to look for the works already done related to this and identify the idea behind every approach and list out what could have been done better. That's enough to create the solution and set the target specifications. Based on the literature survey, the target specifications to achieve and some simulations, the components can be selected. Once the components are selected, then circuit design can be completed keeping in mind the target specifications. After the components were purchased, the proposed idea for solving the problem can be implemented and should be shown for validation

along with the implementation of the circuit with hardware. The next phase of this product is to go under the testing phase and look for the glitches. After the validation of the design and some fine tuning, the product will be ready to use and implement in the real world where it could bring a change and help autism people in communicating with others.

V. PROPOSED SYSTEM

The block diagram shown in Fig.2 of smart gloves for speech impaired people is shown as Fig.2. This system has both hardware and software. Hardware part includes flex sensor, arduino, and accelerometer. Software part includes the programming of arduino according to the gestures. This system is classified into three parts:

1. Gesture input
2. Sensor data processing
3. Output

A. Gesture input

The proposed system takes the sensor readings of flex sensors and accelerometer as the input to mimic the sign of corresponding gesture. Flex sensor is used to produce an output corresponding to the gesture performed by the user. These are attached with the glove, so that it can function like a nerve that sends stimulus to the brain, to send signals to the microcontroller. Some of the gestures are similar in appearance but they represent different alphabets or words. The difference between those gestures is only in the orientation of the hand. For this purpose, to detect the perfect gesture, an accelerometer is implied, which gives the triplet of voltages of x,y,z axes as per the orientation of the hand.

B. Process

Arduino UNO is employed as the microcontroller to take the inputs of flex sensors and accelerometer and process them into a desired output. It has 6, 10 bits ADCs which convert the outputs of flex sensors and accelerometer into a corresponding digital output so that it can be processed. The predefined texts for the gestures are stored in processor memory and if one of them matches with input values, the corresponding text will be output.

C. Output

In today's world , almost all people has either a smart phone or laptop, so that a web UI was created, which will reduce both the cost and size of the product by eliminating the need for an LCD display. The output framed by the microcontroller unit will be displayed in the user interface so that the receiver for the user can understand, what the speaker is trying to communicate.

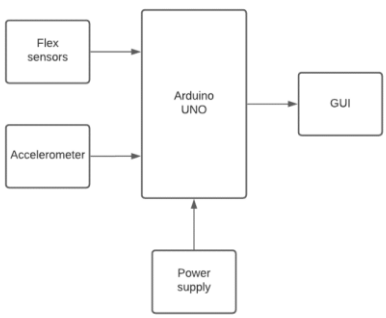

Fig.3. Block diagram

VI. ASSEMBLY OF SMART GLOVE

Arduino UNO: Arduino UNO is an 8-bit microcontroller supported by ATmega 328p microcontroller shows in Fig.3 . This microcontroller can be connected with other devices with USB interface that comes with it, it also has 14 digital I/O ports for connecting to the input and output of external circuits by means of digital signals out of those 14 pins, 6 pins are PWM pins and it has 6 analog input pins which measures input ranging from 0-5V. 6 analog inputs are chosen out of which 4 from the flex sensors and 2 from the accelerometer. Depending on the flex value and orientation of the hand, the corresponding character will be displayed on the graphical user interface. By this way the speech impaired people can communicate with the other people.

Fig.3. Microcontroller Unit

[Source: https://en.wikipedia.org/wiki/Arduino_Uno]

Flex sensor: Flex sensor is a variable resistance component shown in Fig. 4. Unlike other variable resistors it changes resistance value according to the change in the flexed value. It has a resistance value ranging from 30k-70k ohms, 30k ohms corresponds to the lower value of the flex sensor which means when the sensor is flat i.e.,180 degrees and 70k ohms corresponds to the higher value where the sensor flexed in an angle of about 90 degrees. In this case, fixing the sensor in the gloves, in such way the sensor value changes directly in accordance with the change in the position of fingers.

Fig. 4. Flex sensor

[Source: https://www.digikey.in/en/product-highlight/s/spectra-symbol/flex-sensor]

Accelerometer: Accelerometer that shown in Fig. 5. used for finding the orientation of the hand because in sign language for the position of the fingers there are different values for depending on the orientation. So, for that purpose 3 axis accelerometer is used, it measures the acceleration due to

gravity with respect to earth at every point. In this way the controller can keep track of the orientation and the flex values, as a result it returns the sign language values more accurately.

Fig.5. Accelerometer

[Source: https://cdn.sparkfun.com/assets/learn_tutorials/6/3/accel.jpg]

Hand Gloves: The sensors have to be attached to the gloves, and the input to the microcontroller totally relies on the sensor value, so the gloves chosen should be perfectly fit to the hands and at the same time it should be used to flex the fingers. The cricket wicket keeping inner gloves perfectly matches the requirement. It also does not make the finger very sweaty. The total circuit is placed on the gloves, it needs to be make sure that it will be perfectly fit.

Fig.6. Hand Gloves
[Source: https://shop.teamsg.in/product/club-6/]

Breadboard: Since there are many wires from the flex sensors and accelerometer sensor, the product will be clumsy with wires all over without proper arrangement and to provide all the sensors ground value, the common ground must be set. Here that's achieved with a breadboard of 600 points since it provides the room for placing Arduino as well.

VII. SOFTWARE REQUIRED

Graphical User Interface: This is almost the front end of the product. Once the program and controller processing are done, it needs to communicate with other people. This is the part that shows what the speaking impaired people signalling with the sign language. It generally acts like an interpreter between the speaking impaired people and people who doesn't know sign language. In the prototype laptop screen is used as the screen.

Arduino IDE: The Arduino IDE is used for programming the Arduino UNO with some inbuilt functions and a serial monitor for calibrating the sensors. The programming can be done with either C or C++ for structuring. It generally consists of a setup function for initialising the program and it will be executed for once and another function is loop which repeatedly executed the instructions present within it until the power is cut off.

VIII. DESIGN OF CIRCUIT

In the circuit shown in Fig. 8, Arduino is the main board for the project. Arduino UNO is used because of its size and number of input and output pins. Arduino has ATmega 328P microchip whose operating voltage is 5 V. It has 14 digital and 6 analog pins. It has flash memory of 32KB. Flex sensors has two terminals which is connected to Arduino input pins and ground. Some flex sensor has its own flat resistance. Flex sensor used in this project has the flat resistance of about 25K ohm. It is capable of functioning in low voltage. Bend resistance is around 45K – 125K ohm. Flex sensor is cost effective compared to other sensors to measure the deflection and it can give accurate measurements. Accelerometer is connected to Analog terminals A2, A1, A0 for X, Y and Z axes. And then input power and ground is connected to the accelerometer. A 9 Volt Battery is connected to the Arduino to power up the other components. Main reason for using 9 V power supply is compactness and it can be fitted to the glove easily. Circuit connections were given with the help of board.

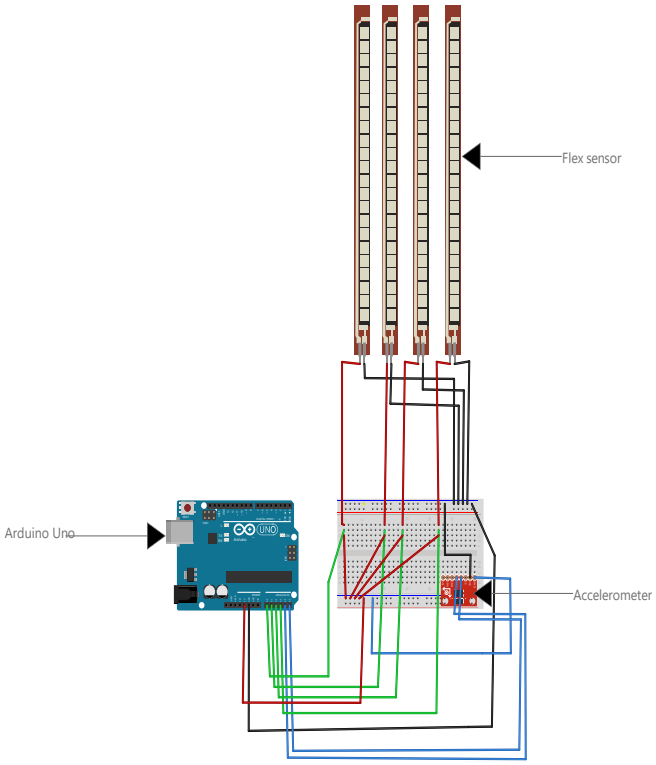

Fig.8. Circuit connection

IX. WORKING PRINCIPLE

The Sign language is actually a sequence of hand gestures. Even it is deflection or bending angle of each finger. The main objective is to detect amount of bending of fingers to determine the correct hand gesture which represents a letter or word. To calculate the amount of deflection many kinds of sensors are available. In this paper, Flex sensor will be the suitable sensor for measuring the deflection of finger.

Flex sensor working is based on the resistivity based on Fig.9 , When the length of material increases, the resistivity also increases.

$$R = \frac{\rho l}{A}$$

R – Resistance

ρ – Resistivity of the sensor

l – Length of the sensor

A - Area of the sensor

Fig.9. Resistance Equation

Flex sensor structure shown in Fig. 10 is so compact and it can be easily fit into hand glove. Using only flex sensor does not reach great accuracy. Along with flex sensor, one more component is added up which is accelerometer.

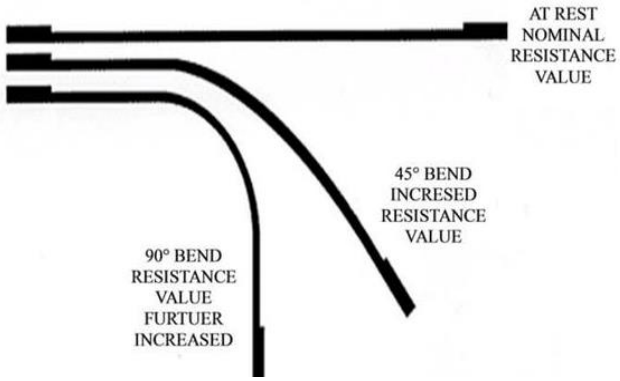

Fig.10. Change in Resistance with bending of flex sensor

[Source: https://www.engineersgarage.com/interfacing-flex-sensor-with-arduino/]

The main purpose of accelerometer is to measure the orientation along all axis. In sign language, there is similar gesture for some numbers and alphabets. This accelerometer greatly helps in solving the similar gesture problem. For specific alphabet, some finger will be bended and some finger remains stretched. Flex sensors are attached to the fingers of the glove. Accelerometer is placed behind the palm of hand. Accelerometer is kind of MEMS sensor. While tilting, the suspended moves between the capacitive plates which creates potential difference. If specific alphabet has to be represented, loop function and flex sensor target values is set. Once the target value is met, it displays the respective alphabet in the screen. For example, in letter A all the fingers are closed except the thumb finger. So, the resistance value of flex sensor in thumb finger will be low than other fingers. AND logic is used if all fingers value is high and thumb finger value is low then display the letter A. Similarly, it is done for all other alphabets and numbers. Expressing each gesture requires certain amount of time. Delay was given for each alphabet to represent it clearly without any mistake. Similarly, this was followed for all the alphabets and numbers. For this process, 9 V battery supply is sufficient to operate all the components. All the sensors and circuit components are attached to the glove.

X. HARWARE IMPLEMENTATION

The Conversion of hand gestures into a letter or word helps hearing impaired people to communicate to everyone easily. Microcontroller, power supply and necessary has already been specified and all these components must be integrated to get a final prototype shown in Fig. 11. The glove was designed for only one hand. Since the prototype is meant for static gestures, it is sufficient for single hand. For dynamic gestures, additional sensors and few components may be required. Once all the components were assembled, glove was checked for its working. Flex sensor values can be calibrated according to the fingers of the user.

Fig.11. Real time implementation

Initially for each alphabet, flex sensor bending angle must be checked and given in order to get precise output. Along with the flex sensor input, accelerometer values also need to be considered because some gestures of alphabet and number have more similarity. So, accelerometer reading is the most important values to be considered.

Fig.12. Sensor's arrangement

After setting all the bending angle value for sensors, glove is checked for each gesture. But still there is misinterpretation in few alphabets. Some words were also displayed using hand gestures.

XI. HARWARE IMPLEMENTATION

The sign language consists of letters corresponding to the fingers position and the orientation of the hand as well. The programming part in the Arduino is implemented in such a way it takes both the flex sensor values and accelerometer values. So, the program should look for both the sensor inputs and only if both the value satisfies for a particular letter it will print the value on the screen. The main part in programming is calibrating the flex sensor, since every sensor fits in different fingers and the impact of bending would be different. As a result, the resistance value also changes. Since the whole letter printing depends on the resistance value, it needs extra caution while calibrating the flex sensor and programming the values. Accelerometer value calibration is no different since it totally depends on the orientation of the hand. While programming, the thing to keep in mind is that it should work for every person. So, the sensor value should be limited with both upper limit values and lower limit values for every letters. In this way, one can also have some quick gestures for some words which they will use the most.

XII. CONCLUSION

A disabled person communicates with others via sign language. The translation of sign language into text and spoken is done so that communication between them is not restricted. The barrier between disable peoples is broken down by using smart gloves for communication. Using smart gloves, disabled people may advance in their careers, which helps the country flourish because the number of disabled people is now in the millions. In comparison to previous proposed systems, this system is more dependable, efficient, easy to use, and a light weight option for the user. This bridges the barrier between speech impaired people and others. This technology will enable persons who are unable to communicate verbally by allowing them to express themselves through gestures. Depending on the user, the speech output can be changed to any language.

XIII. FUTURE SCOPE

Since we only used few signs in this prototype, It believes that additional gestures might be used to detect entire sign language. A convenient and portable hardware gadget with gloves may be made so that a deaf and dumb person can converse with any normal person, anyplace. This gadget has automation applications that can be developed in the future.

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