Design and development of hand gesture recognition system for speech impaired people

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***Abstract*— All over world, deaf and dumb people face struggle in expressing their feelings to other people. There are various challenges experienced by speech and hearing impaired people at public places in expressing themselves to normal people. The solution to this problem is determined in this paper, by the usage of the Indian sign language symbols which are generic to all deaf and dumb people in India. The gestures illustrated by the Indian sign language symbols will be conquered with the support of the flex sensors and accelerometer. The movements included during gesture representation are rotation, angle tilt, and direction changes. The flex sensor and the accelerometer are incorporated over fingers and wrist respectively to acquire their dynamics, a these sensors are fitted over the data glove. These voltage signals will then be processed by microcontroller and sent to voice module, where the words voice outputs are stored and play backed equivalent to each word values to produce the appropriate voice words with the help of the speaker.**

Keywords—Indian sign language, speech impaired, flex sensors, accelerometer and voice module.

I. INTRODUCTION

The language used by speech and hearing impaired to represent themselves is known as Sign Languages. But these languages vary from one country to other, as it is not common to all people. Some of the main challenges experienced by speech and hearing impaired people while communicating with normal people were social interaction, communication disparity, education, behavioral problems, mental health, and safety concerns. As a result of these obstacles, deaf and dumb people are discouraged to speak out about themselves or their situations in a public place or emergency cases or in a private conversation.

Moreover the language diversify is very vast in India, from place to place hence a common mode of connection was needed for speech and hearing impaired people. This resulted in the usage of the Indian Sign Language symbols between deaf and dumb people to interact among them, but it cannot be understood by other normal people. In this paper, Indian Sign language [ISL] has been used. ISL has its own specific syntax, grammar, alphabets, words and numerals. Hand Gestures made by using these symbols are the effective way of communication by speech impaired people to express their idea or meaning. These gestures are made with the help of fingers, hands, wrist movements and elbow movements for different sequence of words. Here two aspects are being governed as one with only finger position without changing hand position and orientation and the other one is change in both finger and hand position and orientations. The main need arises when these sign language symbols are not understood by normal people, as most of them would not have studied ISL. As in real time image processing methods, only a single individual can be benefited by capturing his or her image and processing it into text or speech. But in this paper, any speech impaired people hand gesture movements can be captured by the flex sensors and accelerometers and produced as voice output through the voice module.

Researches have been done for so many years in the Hand gesture interpretation system using various sign languages. As mentioned in paper [1], the sign language gestures are converted into voice for a single alphabet or a complete string by concatenating each and every word and thereby forming the full meaningful words, but it was done only for both American and Pakistan Sign Languages. The method described [2] aims to help patients with wrist impairments to perform some of their daily excercises.In one of the research method [3] American Sign Language have been used, where the boundary of the gesture image depicted by the speech impaired people was approximated into a polygon. Then on further image processing Douglas Peucker algorithm using Freeman Chain Code Direction the words was determined. ISL have also been used in a research paper [4] where each set of signs have been represented by the binary values of the `UP' &`DOWN' positions of the five fingers. The respective images of the symbols was dynamically loaded and converted into text. A material known as Velostat was being used in one of the papers [5] for making piezo resistive sensors, then these sensors was used to detect bend in fingers. This data was mapped to a character set by implementing a Minimum Mean Square Error machine learning algorithm. The method used in one of the research paper [6] is the usage of sensor gloves for detecting hand gestures which uses British Sign Language system. Here only the normal hand gestures are depicted, but not to any sign language symbols pertaining to any country was captured. The outputs are produced in the text format using LCD and audio format using flex sensor. One of the researches [7] was on the robust approach for recognition of bare-handed static American Sign Language using a novel combination of the Local Binary Pattern histogram and Linear Binary Support Vector Machine (SVM) classifiers. In one of the papers [8] it was mentioned to use a device which detects and tracks hand and finger motions for Arabic Sign Language. It is done by the data acquisition using the Multilayer Perceptron networks using Naves Bayes classifier. In the research approach [9] discussed for the American Sign Language uses glove with six colored markers and two cameras to extract the co-ordinate points .The detection of the alphabets is done by the Circle Hough Transform and backpropagation of the Artificial neural network. One of the ways [10] to detect American Sign Language was capable of recognizing hand gestures even when the fore arm was involved and also its rotation. It has been implemented using Principal component analysis to differentiate between two similar gestures.

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Thus there were various limitations on the previous researches done so far in the field of Sign language interpretation system. Some of them were usage of the image processing method, as it will be restricted to only individual images being captured and processed, hence it can be dynamically loaded and calculated for different persons using it. Only finger gestures and alphabets have been obtained from the sign language movements and were produced as output for other country languages as British, American and Pakistan. Also the distance between the camera and the person may disturb the accuracy. Therefore in this project, the gestures for words in Indian sign languages have been used and eight commonly used words are produced as voice outputs. The movements are captured with the help of flex sensor and accelerometer and can be changed dynamically with the change in person and hand orientations.

II. MATERIALS AND METHODOLOGY

The hand gesture recognition setup represented in this paper comprise of the Data glove, Sensory part (flex sensors and accelerometer), Amplifier, PIC Microcontroller, voice module and speaker. The Fig.1.shows the block diagram of the ISL hand gesture recognition system.

A. Data glove

A data glove is an associative device , which facilitates tactile sensing and fine-motion control. It is is specially used to capture the shape and dynamics of the hand in a more effective and direct manner. The flex sensors are being fixed over each finger and accelerometers over the wrist part. These sensors are being fixed onto the cloth type data glove by the use of the cello tape or glue. The Fig.2 shows the data glove that was worn by the speech impaired people and which does acquisition of the gestures with the aid of the flex sensors and acclerometers.

B. Sensory part

The sensory part consists of flex sensors for gaining the finger arrangements and acclerometer for the wrist spins.In the flex sensor, the resistance varies equivalent to

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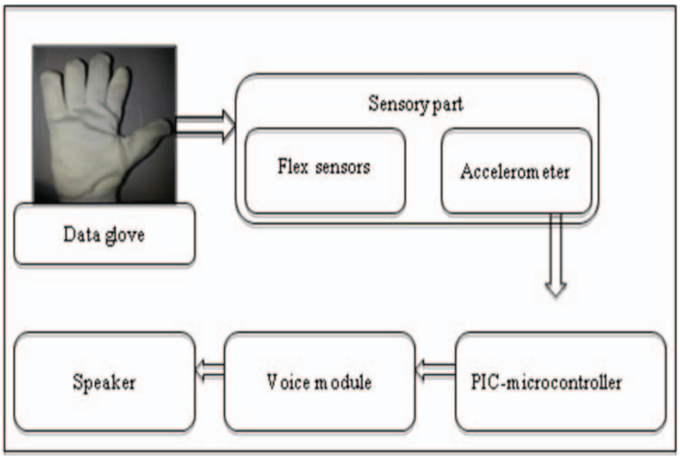

Fig. 1. Block Diagram of the ISL hand gesture recognition system

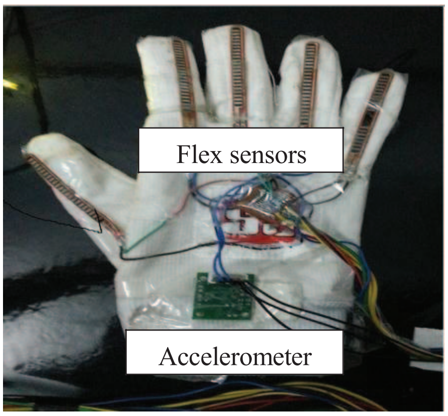

Fig. 2. Data glove fitted with senors

the bending of the sensors. This resistance is then converted to voltage value by the use of the voltage divider circuit using a

10kΩ resistor. Similiarly the voltage conversion is done for each flex senor situated over the fingers. The accelerometer consist of 3 axes as x,y,z axes and produces 3 different set of values corresponding to each axis location and based on the wrist movement or orientation made in the hand gesture.

C. PIC Mircrontroller

The microcontroller is used to govern the operartion of the signal vlaues that are being handled from the sensors. Thus the outcome voltages of flex sensors and the accelerometers are given as inputs to the to the ports of A and E of the PIC microcontroller for further processing. The other end of all the sensory part is connected to common ground. These signal values are converted to digital by the use of the inbuilt ADC in the microcontroller.

D. Voice Module

Signals from the microcontroller was then given to the voice module. The voice module consist of eight channels, in which eight words can be recorded. The voice module can be operated in various modes as parallel and serial modes. The voices were recorded when the both signals CE(reset sound track) and RE(record) are low till the rising edge of the trigger. Then the same voice can be play back when only RE is high and a high to low edge is applied as trigger. The sound of the words can be heard loud and clearly with the help of the speaker. The setup also incorporate a LCD panel to display the flex sensor and acclerometer voltages.

III. Experimental results

All the sensors on the data glove were first tested. The flex sensor and the accelerometer readings were observed with variation in their position, rotation and bending for 5 trials.

The bending in hand is being determined at three bends of the bones of the hand known as distal, middle and proximal phalanges as mentioned in TABLE I. of the flex sensor readings. The Fig. 2.shown is the experimental setup of the project used for the Indian Sign Language gesture Interpretation system. The inference was observed from these sensor readings of flex sensor in TABLE I.and accelerometer in TABLE II., at different positions and trials. For the flex sensor, the voltage across the finger when the sensor is straight is 3.5V, for a power supply of 5V is given. The Voltage drop across the flex sensor was maximum at the middle phalanges bend and minimum when at the proximal phalanges bend. For the accelerometer, the maximum values were observed for X-axis when hand turns right, Y-axis when hand moves up and Z-axis when hand slants to up position. The trial readings were taken and from those the final readings were derived and given as mean ± standard deviation. On calculating the coefficient of variance for these readings, which is very less than one which indicates these values have good repeatability and reproducibility. The coefficient variance is the ratio of standard deviation to mean to each flex sensor and accelerometer values. Once all the flex sensors and accelerometer were tested with their good reputable readings, the experimental setup shown in Fig. 3. was arranged. The Fig 3. Shows the Experimental set up of the ISL hand gesture recognition system. The data glove fitted with sensors after testing was connected to a PIC microcontroller, then to a voice module, speaker and LCD to hear the voice signals.

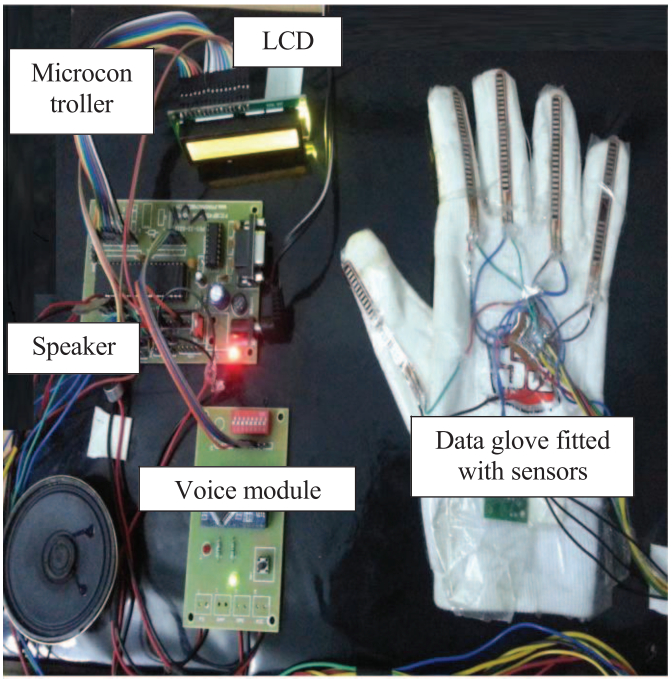

Fig. 3. Experimental Setup of the ISL hand gesture recognition system

TABLE I. Flex Sensor readings

Finger Name	Nobend (Mean±Stddev) (V)	Distal phalanx Bend (Mean±Stddev) (V)	Middle phalanx Bend (Mean±Stddev) (V)
Thumb	3.498±8.944e-4	3.536±0.01073	3.662±3.57e-3
Index	3.504±1.788e-3	3.742±3.577e-3	3.872±8.944e-4
Middle	3.508±3.577e-3	3.786±2.68e-3	3.898±8.944e-4
Ring	3.506±2.68e-3	3.694±1.788e-3	3.842±3.577e-3
Little	3.502±8.944e-4	3.536±1.788e-3	3.694±1.788e-3

Subsequently after setting the full plan of the system, with the consideration of tested both the sensors for their repeatable values. After this the data glove with flex sensors over each finger and accelerometer over the wrist was worn out by the speech impaired people. Once they get ready with their gestures and start expressing in hands, simultaneously the voltage signal equal to the bend and rotation will be fed to the microcontroller. The flex sensor voltage of each finger movement according to each word gesticulation was noted down depending on the bend in each word. Similarly it was done for each finger's various angle bends. Also in the accelerometer all the x, y, z axes variations were calculated corresponding to each words rotation, up, down positions. This scheme of measurements was repeated for different set of speech impaired people and for a number of trails. By this approach the minimum and maximum threshold of each finger and wrist was calculated proportionate to eight words.

From these measurements the average values of the sensor readings were computed. The mostly commonly used eight set of words were listed, noted their each finger and wrist movement and their corresponding values. The selected eight words were Monday, Tuesday, Thursday, What and Which. The Indian sign language symbols for these words are the gesture movements that was obtained from the speech impaired people after they wore the glove fitted with seniors. The TABLE III shows the derived and average values of one of the words which was reprented through Indian sign language symbols. The graph shown in Fig.4. represnts the sensor readings of a single word Monday .

Similarly the same procedure was repeated for all other words by calculating their minimum and maximum voltages for their corresponding ISL gestures made by speech impaired people. These values will be given to the voice module after processed by the PIC microcontroller. In the voice module ,the voltages which are received from the sensors and microcontroller select their appropiate words's sound output. If the match between the word and voltage readings are equivalent , then voice of the words can be heard through the speaker. The same custom of steps will be applicable for all the other word's voltages and their respective voice turnouts can be heard as output.

IV. CONCLUSIONS

In this paper, the usages of the hand gesture made by speech and hearing impaired people have been made successful to interpret their expression of words. Hence the gesture for each word was acquired with the help of the flex sensors and accelerometers. Their corresponding distinct voltages were fed serially to the setup. The data on processing by the microcontroller and voice module would generate the consonant words which can be heard by normal people with the help of the speaker. Thus, the communication gap between normal and speech and hearing impaired people is reduced. The discussions of the Indian sign language have been made and the symbols of the eight commonly used words was captured and produced as voice output. Hence this research provides an elucidation for all the obstacles faced by all speech impaired people, as from this they will be satisfied, motivated and gain self confidence that their feelings will also be understood by other people.

At present the gestures made by only single hand have been captured, but in future it can be extended to symbols produced by both of the hands. Also as far as now only eight words are produced in the voice module, which can also be enhanced to more number of words as voice turnouts.

TABLE II. ACCELEROMETER READINGS

Axis / Position	Up (Mean±Stddev)(V)	Down (Mean±Stddev)(V)	Tilt right (Mean± Stddev) (V)	Tilt left (Mean± Stddev) (V)	Slant position (Mean±Stddev)(V)
X axis	1.644± 1.788e-3	1.688± 3.577e-3	1.912± 8.944e-4	1.358±8. 944e-4	1.46± 4.472e-3
Y Axis	1.352± 3.577e-3	1.858± 3.577e-3	1.744± 1.788e-3	1.698±8. 944e-4	1.386± 2.683e-3
Z-axis	1.45± 4.472e-3	1.394± 2.68e-3	1.512± 3.577e-3	1.442±3. 577e-3	1.312± 3.577e-3

TABLE III. SENSOR READINGS FOR WORD

Sensor value for word-Monday	
Position	**Voltage Values (Mean±Stddev)((V)**
Thumb finger	4.68±0.014142136
Index finger	3.71±0.0083666
Middle finger	4.3±0.021679483
Ring finger	3.96±0.008944272
Little finger	4.37±0.010954451
X-axis	1.83±0.01
Y-axis	1.58±0.0083666
Z-axis	1.42±0.008944272

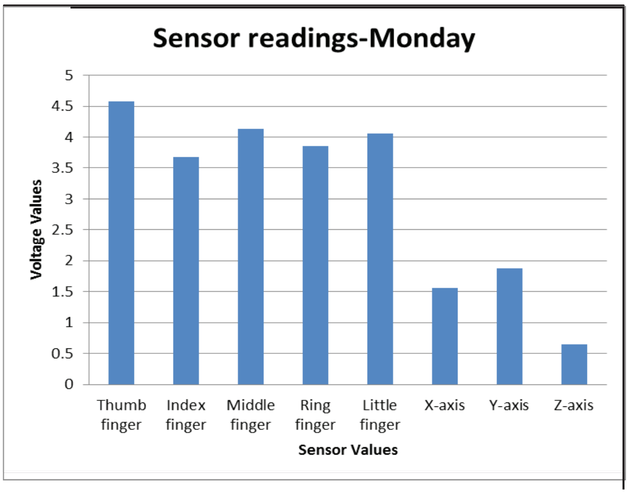

Fig. 4. Graphical Representaion of the Sensor readings for word

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