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Gift of Voice to Mute: Hand Gestures Converted to Text and Voice

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***Abstract*:** Though Sign language using gestures and facial expressions helps deaf and dumb people to express their thoughts, normal people do not learn sign language and therefore not able to comprehend it thus causing a barrier between the two and a big cause of frustration. With the objective to lower the barrier in communication by opening up conversations between signers and speakers, we have converted sign language to text and speech using flex sensors, Arduino Uno, HC-05: Bluetooth and a mobile device as the hardware and Arduino IDE and MIT App Inventor as the software. Normal driving gloves have been converted to wireless data smart gloves by fitting them with flex sensors along the length of each finger and the thumb and accelero sensor. The signals are passed on Arduino Uno which converts analog signal from the sensors to digital signals. The signal is then passed on to a Bluetooth device HC-05.Then signal is transmitted to a mobile device on a Bluetooth app. Signal is then converted into a voice message. This low cost solution is affordable, portable and easily customizable with additional Feature for GPS location for safety purposes.

***Keywords*:** Sign language, Flex sensor, Arduino Uno, Gestures, MIT App Inventor

I. INTRODUCTION

In a country with over 28 national languages, Jhoti Prajapati did not speak at all. When she turned 3, her mother visited a doctor and was explained the reason of her silence: Jhoti was born deaf. According to the 2011 Indian census, there are roughly 1.3 million people with "hearing impairment." In contrast, India's National Association of the Deaf estimates that 18 million people i.e. about 1% of the Indian population is deaf.

Though dumb people use sign language, they find difficulty in communicating with others who don't understand sign language thus causing a barrier between the two because communication is a fundamental aspect of our life. Helen Keller has rightly said, "Blindness separates people from things, but deafness separates people from people." The blind people can talk freely by means of normal language whereas the deaf-mute people have their own manual-visual language popularly known as sign language. Sign language is a non-verbal communication used by deaf and dumb which uses gestures to express thoughts, gesture being a particular movement of the hand with shapes being made out in the form of fingers. Although many sign languages for many dialects exists but it always requires either a translator or both the parties to know the particular language. Therefore it has become a vital need for the society to develop effective sign language recognition systems. However, all the early solutions help only those who are familiar with sign language. According to the latest census, India has only 700 schools which teach sign language and only 250 certified sign language interpreter, translating for a deaf population of between 1.8 million and 7 million. This wide range is because the Indian census does not track the number of deaf people; instead it documents an aggregate number of people with disabilities. Unlike American Sign Language (ASL) and sign language of European countries, ISL is in rudimentary stage of its development and unlike English and Hindi, it is not written. It has sadly not acquired an official recognition as a language. Also signs mean completely different things in two different places due to lack of standardization. On top of it, there is only very small percentage familiar with sign language in India thus making it important to reach those people who have just no means to communicate.

II. RELATED WORK

Innovative Systems have been developed previously with the same intent, few of which are:-Embedded Based Hand Talk Assisting System for Deaf and Dumb was developed in March 2014 by J. Thilagavathy who used a simple method by storing and running audio using keypad.[1] However, it does not use sign language. Sigh language to speech converter was developed in May 2014 by R.R Itkarkar and Anil V. Nandi who converted the gesture to audio with the help of MATLAB.[2] But the major drawback about the system is that it always requires a computer for conversion and it is non-portable. Interactive Glove was developed in November 2015 by Mandar Tawade which converts alphabet from sign language to audio but no words are converted of sign language.[3] Talk Aloud Gloves developed in April 2016, sense gestures with flex sensors and audio is produced with the help of computer. The major drawback of this system is that it requires computer and there is no way for other person to

communicate. [4] In March 2017, hand glove with flex sensors and Atmel ATmega168 microprocessor was made to convert hand gestures to auditory speech and another module used an Android App with Google Speech API to convert speech to readable text. [5],[6] In October 2018, hand talk assistive technology was developed by T.Jaya and Rajendran.V who processed hand gestures using flex sensors through wireless RF communication.[7]

III. THEORY

The two main sections of hand gesture recognition system:

III.I HARDWARE MODULE

FLEX SENSORS: 'Flex Sensor' or 'Bend Sensor' depends on the bend angle of the sensors and changes resistance accordingly. The sensors produce resistance when substrate is bent. More the bend, higher is the resistance.

Features:

- 5-volt input and output between 0 and 5 Volt (V)
- Resistivity: varying with the sensor's degree of bend and the voltage output changing accordingly.(Figure1)
- An un flexed sensor has a resistance of about 10,000 ohms. As the flex sensor is bent, the resistance increases to 30- 40 kilo ohms at 90 degrees.

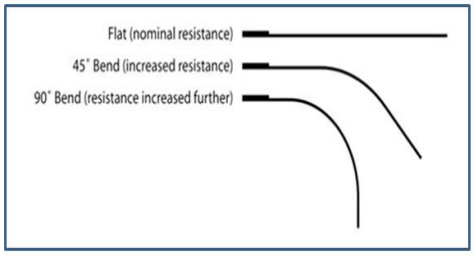

Figure 1: Flex sensors showing different resistances for different bending

Uses: Flex sensors are commonly used in numerous applications such as –Robotics, Automotive controls, Fitness Products, Medical Devices, Virtual Reality gaming consoles, etc.

ARDUINO UNO BOARD: ATmega328 is used to build a microcontroller board called Arduino Uno. The features include 16 Megahertz (MHz) ceramic resonator, six analog inputs, Universal Serial Bus (USB) connection, power jack, reset button, 14 digital Intake/output (I/O) pins and an In Circuit Serial Programming (ICSP) header.

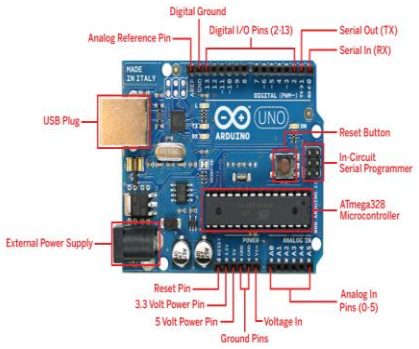

Figure 2: Labelled diagram of the Arduino Uno

- Flex sensor 1 connects to A0 pin of arduino.
- Flex sensor 2 connects to A1 pin of arduino.
- Flex sensor 3 connects to A2 pin of arduino.
- Flex sensor 4 connects to A3 pin of arduino.

HC05 (BLUETOOTH MODULE)

- The Bluetooth SP has 2.4Giga Hertz (GHz) radio.
- A transparent serial connection can be setup with the use of HC-05 that uses Bluetooth Serial Port Protocol.
- To make it a great solution for wireless communication Master or Slave configuration is followed by the HC-05 Bluetooth Module. The slave module does not connect to other blue tooth devices but accepts connections, whereas Master connects to many other devices.

Figure 3: Bluetooth Module HC – 05

ACCELEROMETER: ADXL 335 is a small, thin, low power, complete 3-axis accelerometer with signal conditioned voltage outputs. The product measures acceleration within a minimum full scale range of ± 3grams. (Figure 4)

- 3-axis sensing
- Small, low-profile package
- 4 mm × 4 mm × 1.45 mm LFCSP
- Low power - 350 microampere(μA)
- Single-supply operation
- 1.8 V to 3.6 V

Figure 4: Accelerometer ADXL 335

2KB INTERNAL EEPROM:

Internal Electrically **E**rasable **P**rogrammable **R**ead **O**nly **M**emory is a type of non-volatile memory which can be programmed, erased, and re-programmed electrically while it is on the circuit board. It has been used to store data that should not be lost when the system is powered down.

ALPHANUMERIC LCD (LIQUID CRYSTALLINE DISPLAY):

Alphanumeric LCD is liquid crystal display, with the purpose of displaying letters and numbers. (Figure 5 a). Main characteristic of alphanumerical LCD is the placing of its segments. The screen is divided into many indicators. Each indicator has either enough segments for displaying letters and numbers or it is formed from matrix of little square segments (pixels). (Figure 5)

Figure 5 : Alphanumeric LCD display

III.II. SOFTWARE ALGORITHM

ARDUINO IDE: OPEN SOURCE IDE that provides an interface for all the Arduino boards. Written in Java, this open source Integrated Development Environment (IDE) helps interfacing with all Arduino boards & node MCU modules. It is supported by Mac OS X, Linux and Windows. The interface of the software is very easy to use, and has loads of inbuilt libraries. (Figure 6) Sketches or the programs are saved using ".ino" extension.

Figure 6: Interface of the Arduino IDE

Arduino Software Integrated Development Environment (IDE) programmes the UNO. Select "ArduinoUno" from the Tools > Board menu (according to the microcontroller on your board). To allow uploading new code without use of external hardware programmer it comes with The ATmega328 on the Uno comes pre-programmed with a boot loader.

MIT APP INVENTOR: MIT (Massachusetts Institute of Technology) App Inventor: Apps for Android OS can be built using the MIT App Inventor. I simply dragged the required object and dropped it where desired by using the block interface. On 12th July, 2010 the app inventor was freely available across all devices and was launched publically on 15th Dec, 2010. But the MIT version was not launched until March, 2012. (Figure 7)

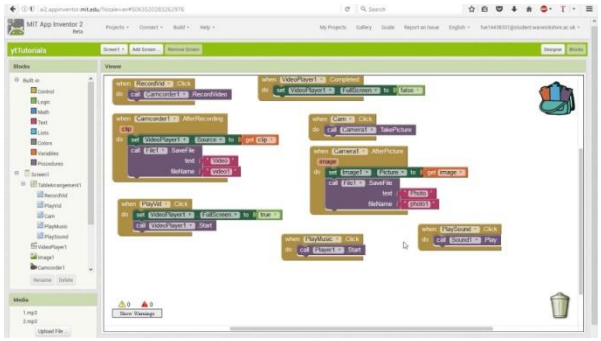

Figure 7: Block Interface MIT app inventor

IV. METHODOLOGY

Normal driving gloves can be converted into wireless data smart gloves by fitting them with flex sensors along the length of each finger and the thumb and accelero sensor. The signals are passed on Arduino Uno which converts analog signal from the sensors to digital signals. The signal is then passed on to a Bluetooth device HC-05.Then signal is transmitted to a mobile device on a Bluetooth app. Signal is then converted into a voice message.(Figure 8)

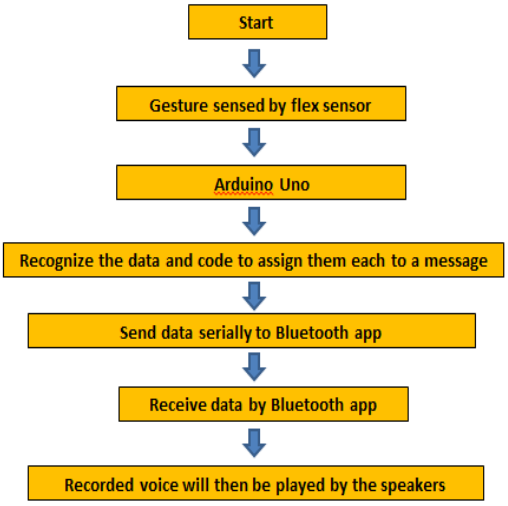

Figure 8: Algorithm

Proposed method:

1. The glove is fitted with flex sensors along the length of each finger.(Figure 9a)
2. The output from flex sensors depends on the amount of bend produced by the sign. A group of signs that represent words are collected as the data set for the system.
3. The accelerometer helps in knowing the orientation of the hand in the 3 axes namely X axis, Y axis and Z axis
4. Using the flex sensors and accelerometer , we can create different symbols and assign texts to them that can be used in daily life frequently
5. Of the 15 texts, 10 have been fixed that are used in the most general case while the rest 5 are customizable and can be changed according to the user in the application.(Table 1)
6. To make the Arduino remember them even after the power goes off the 2KB internal EEPROM (Electrically Erasable Programmable Read Only Memory) is being interfaced. .(Figure 9b)
7. A 16x2 Alphanumeric LCD (Liquid Crystalline Display) is also integrated that simultaneously shows the messages on it and makes them easy to read and interface.
8. Since we are using 4 flex sensors we can create a total of 2^4 = 16 combinations along with 5 orientations results in 80 such symbols. In future we can implement the sensors in all 10 fingers resulting in a total of 2^{10}x5 i.e. 5120 combinations.
9. A message can be sent for help in case the user is in trouble.

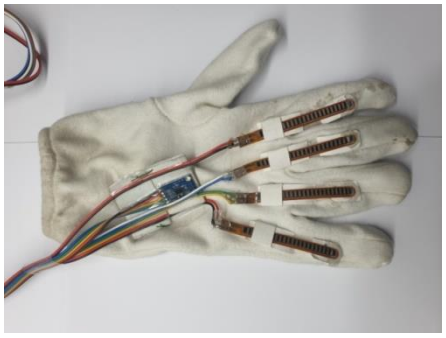

Figure 9a: Normal gloves converted to smart data gloves

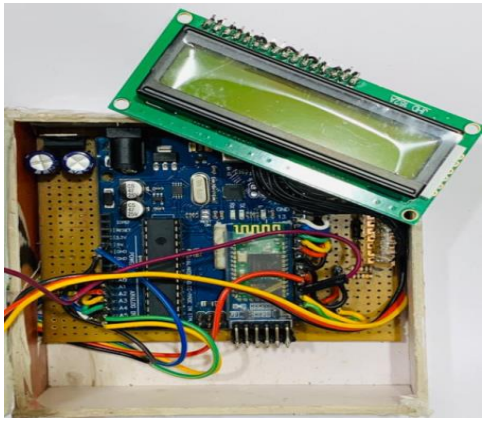

Figure 9b: Hardware

V. WORKING

The flex sensors are connected as shown in Figure 10 a and circuit Figure 10 b.

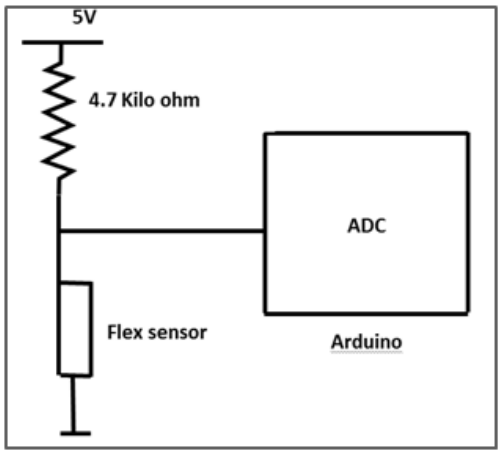

Figure10a: Connections of Flex sensors

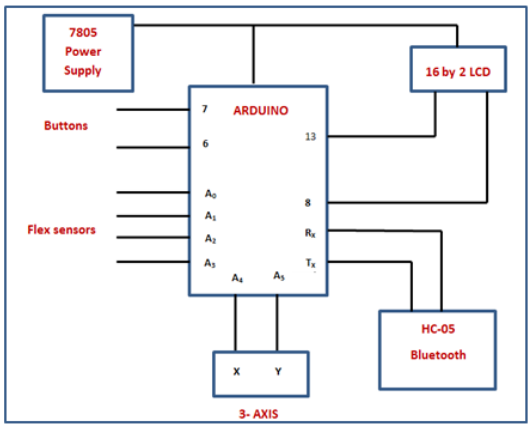

Figure 10 b: Circuit diagram

The voltage present at the input of arduino is V_0= 5 by R flex

$$V0 = \frac{5 \times RFLEX}{RFLEX + 4.7k}$$

On Different amounts of bends, flex shows different resistances and hence different voltages. These changes are measured by a 10-bit ADC. It converts valves from 0-5V to 0-1023. It was observed that whenever the flex (i.e. finger) is open it gave a value of approximately 900 ohms and on bending 88ohms. Hence thresholds are made accordingly as shown in Table 1.

Table 1: ADC values

	Open	Closed	Threshold
Flex sensor 1 (Index finger)	850	1000	920
Flex sensor 2 (Middle finger)	800	920	850
Flex sensor 3 (Ring finger)	830	1000	900
Flex sensor 4 (Little finger)	840	1010	920

Based on each flex closed being assigned a value of 1 and open assigned a value of 0, the data obtained was fed as shown in table 2.

FIXED MESSAGES (all in upward orientation)

Table 2: Fixed messages fed as per flexion of fingers in upward orientation

Flex 1	Flex 2	Flex 3	Flex 4	Messages
1	0	0	0	Hello, how are you doing?
0	1	0	0	I need a glass of water.
0	0	1	0	Can you help me a little?
0	0	0	1	Open the door for me.
1	1	0	0	Can you help in the stairs?
0	1	1	0	I need something to eat.
0	0	1	1	Turn off the lights
1	1	1	0	Nice meeting you.
0	1	1	1	Goodbye I got to go.
1	1	1	1	XYZ(for GPS communication)

The way flex sensors are recorded on ADC, the values from 3 axes are also taken and they are in range from 280-350. (Table 3) (Figure 11)

Table 3: Value in 3 axes

X value	Y value	Orientation
>350	× (*Any mid*)	Back
<280	× (*Any mid*)	Front
×	>350	Right
×	<280	Left
×	×	Centre

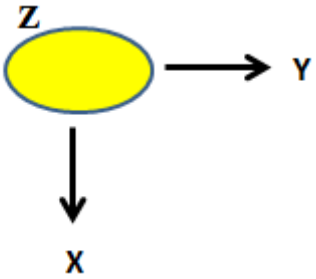

Figure 11: Three axes (X, Y, Z)

It is observed that in case of tilt in direction of arrow, the value includes up to 360-370 in opposite direction up to 280.

VI. RESULTS

1. Fixed messages and help message

Table 4: 10 messages have been fixed along with help message

2. Customized messages:

5 extra messages can be customized and stored in different orientations by the user as per his desire, one of which is as shown (Table 5):

Table 5: Sample customized message

VII. ADVANTAGES

- Low Cost Solution, hence affordable to common people.
- More adaptable to daily lives of people
- Portable
- GPS location ability by sending message when in trouble
- Ability to customize signs and messages helps deaf and dumb who are not familiar with sign language to communicate.

VIII. CONCLUSION

Sign language is a useful tool to ease communication between mute community and normal people. Yet a communication barrier exists. This project aims to lower this gap. The main feature of this project is that the gesture recognizer is a standalone system, which is applicable in daily life. Its Low cost, compact system is flexible to users and it takes less power to operate. This project shows an implementation of a Hand Gesture Recognition System that can be used by a fraction of the society so that they stand an equal chance in putting forward their ideas and overcoming the barrier of language.

IX. FUTURE WORK

- The delay time between giving the signal and the message playing and between one message and another can be reduced.
- A similar glove can be designed for complete sign language of different dialects. And a feature to choose to speak a desired language can be inserted. This can also be used for translation of different sign languages.
- This prototype could be developed so that many digital devices such as phones, laptops and tablets, etc. can be connected to some source and can receive text format of the sign language that is used to communicate. This allows public speaking for the speech impaired people.
- Flex sensors extending to wrist will help in interpreting a wider number of gestures.

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AUTHOR'S PROFILE:

Seher Taneja is presently a student of Std XI, Springdales School, Dhaula Kuan. She has a keen interest in Applied Physics and Mathematics. She has conducted several award research projects at the National level and has an urge to solve real world problems. She wants to create problem-solving projects and apply them to the real world using entrepreneurship. Her research paper on "Comparative Evaluation of Vital Capacities of Athletes, Singers and Other Students Of Age 13-14 Years- A Cross Sectional, Observational Study" has been published in the Journal Of Emerging Investigators and has been presented at the 6th King John Price Paediatric Respiratory Conference 2020 .She is presently working on " Comparative Evaluation Of Prevalence Of Pre-Hypertension And Hypertension In Relation To Anthropometric Measures In Urban Private School And Urban Slum Indian Students Of Age 13-14 Years - A Cross Sectional, Observational Study." As the Vice President of Indian Science and Technology Campaign, she has been working to bring about a wave of inquisitiveness in children to help them become future leaders by STEM education.

Mandeep Kaur Sukhija pursued Bachelors of Science Masters of Science with major in Physics from University of Delhi, India. She specializes in Electronics and Communication. After her post graduation she took up Masters in Environment and Ecology. She is currently working as a Post Graduate teacher at Springdales School, New Delhi, India. With an experience of more than 25 years she has taken up research projects with her students in the field of STEM and Environment. In 2017, the Directorate of Education, Govt. of NCT of Delhi, honoured her with the State Teacher's Award. She also received the Pied Piper Award by Springdales Education Society for her contribution for Project Based learning and developing innovative mind sets amongst her students. Her students have won laurels and accolades at National and International level competitions.

