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Deaf-Mute Communication Interpreter

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***Abstract* - Communications between deaf-mute and a normal person have always been a challenging task. The project aims to facilitate people by means of a glove based deaf-mute communication interpreter system. The glove is internally equipped with five flex sensors, tactile sensors and accelerometer. For each specific gesture, the flex sensor produces a proportional change in resistance and accelerometer measures the orientation of hand. The processing of these hand gestures is in Arduino. The glove includes two modes of operation – training mode to benefit every user and an operational mode. The concatenation of letters to form words is also done in Arduino. In addition, the system also includes a text to speech conversion (TTS) block which translates the matched gestures i.e. text to voice output.**

Keywords—Deaf-Mute, communication, gesture, Flex sensor, tactile sensors, accelerometer, TTS.

I. INTRODUCTION

About nine billion people in the world are deaf and dumb. How often we come across these people communicating with the normal world? The communication between a deaf and hearing person poses to be a serious problem compared to communication between blind and normal visual people. This creates a very little room for them with communication being a fundamental aspect of human life. The blind people can talk freely by means of normal language whereas the deaf-dumb have their own manual-visual language known as sign language. Sign language is a non-verbal form of intercourse which is found amongst deaf communities in world. The languages do not have a common origin and hence difficult to interpret. Deaf-Mute communication interpreter is a device that translates the hand gestures to auditory speech.

A gesture in a sign language, is a particular movement of the hands with a specific shape made out of them. Facial expressions also count toward the gesture, at the same time. A posture on the other hand, is a static shape of the hand to indicate a sign.

Gesture recognition is classified into two main categories i.e. vision based and sensor based [5][6]. The disadvantage of vision based techniques includes complex algorithms for data processing. Another challenge in image and video processing includes variant lighting conditions, backgrounds and field of view constraints and occlusion. The sensor based technique offers greater mobility.

The main aim of this paper is to present a system that can efficiently translate American Sign Language[1] gestures to both text and auditory voice. The interpreter here makes use of a glove based technique comprising of flex sensor [7], tactile sensors [2] and accelerometer. For each hand gesture made a signal is produced by the sensors corresponding to the hand sign [3] [9] the controller matches the gesture with pre-stored inputs.

The device not only translates alphabets but can also forms words using made gestures. Training mode is offered in device so that it fits every user and accuracy is increased. The device can also be made to translate larger gestures that require single hand movement.

II. MATERIALS AND METHODS

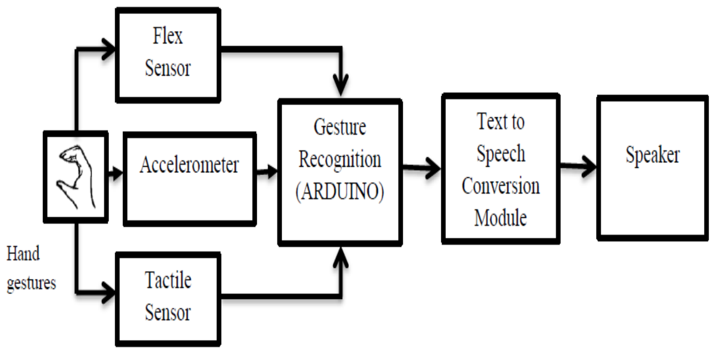


Figure 1. Block diagram of system

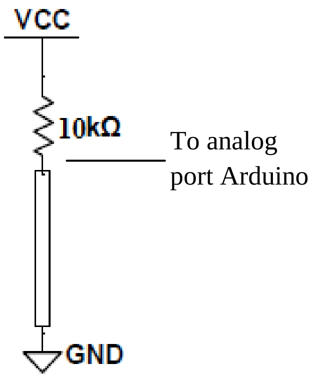
Figure 1 shows the entire block of Deaf-Mute communication interpreter device. The controller used in the device is an Arduino. Five flex sensors are used to measure the degree of bending of the fingers. The flex sensors are interfaced with the controller using the voltage divider circuit. Accelerometer is directly interfaced to the digital ports as it includes the signal conditioning circuit. Three tactile sensors are used to improve accuracy of letters M, N and T. The device contains two more tactile sensors for training mode and word formations. This is interfaced with the digital ports of controller to feed in the digital data.Arduino processes the data for each particular gesture made. The controller has two modes of operation – training mode and operational mode. In training mode the gesture are made by user and the voltage levels are stored in EEPROM. In operational mode the data is being compared with predefined values and the matched gestures are sent to text to speech conversion module. The module consists of TTS block and SpeakJet. The output is processed and heard via a speaker.

A. ARDUINO WITH BUILT IN ATMEGA 328

Arduino is an open source platform based on simple microcontroller board. The controller used in the device is Arduino duemilanove with inbuilt atmega328 in it. Atmega328 has 32KB on-chip flash memory for storing codes of which 2KB used for boot loader. It also includes a 2KB of SRAM and 1KB of EEPROM. The program that is developed is to be stored on the flash memory of the controller. The Arduino software also includes a serial monitor which allows data to be sent to or from the Arduino board.

B. FLEX SENSOR

Flex sensors are resistive carbon elements. When bent, the sensor produces a resistance output correlated to the bend radius [9]. The variation in resistance is approximately 10 to 30 KOhm's. An unflexed sensor has 10Kohm resistance and when bent the resistance increases to 30Kohm at 90^o [3]. The sensor is about ¼ inch wide, 4-1/2 inches long.



$$V_{out} = V_{in} [R_1 / R_1 + R_2]$$

Figure 2. Voltage divider circuit

The sensor is incorporated in device using a voltage divider network. Voltage divider is used to determine the output voltage across two resistances connected in series i.e. basically resistance to voltage converter. The resistor and flex forms a voltage divider which divides the input voltage by a ratio determined by the variable and fixed resistors.

C. TACTILE SENSORS

A tactile switch also known as momentary button or push-to-make switch is commonly used for inputs and controller resets. These types of switches create a temporary electrical connection when pressed. One pin is supplied with +5 volts and the other pin is grounded. This is connected to the digital pin of Arduino. Output is grounded as switch is pressed and high otherwise.

D. ACCELEROMETER

Accelerometers are used for tilt sensing. They measure both static and dynamic acceleration. The sensor has a g-select input which switches the accelerometer between ± 1.5g and ±6g measurement ranges. It has a signal conditioning unit with a 1-pole low pass filter, temperature compensation, self-test, and 0g-detect which detects linear free fall.

E. TEXT TO SPEECH CONVERSION

The translator consist of text to speech module that allows the device to translate the gesture once recorded. The encoder (TTS256)-synthesis (SpeakJet) pair includes text to speech modality without loading microcontroller. The output text of Atmega 328 is converted to sound by TTS.The TTS256 is a 28 pin DIP, 8 bit microprocessor programmed with 600 letters to sound rules. The built-in algorithm allows real time translation of English ASCII characters to allophone addresses. This is used along with SpeakJet to facilitate text to speech conversion.

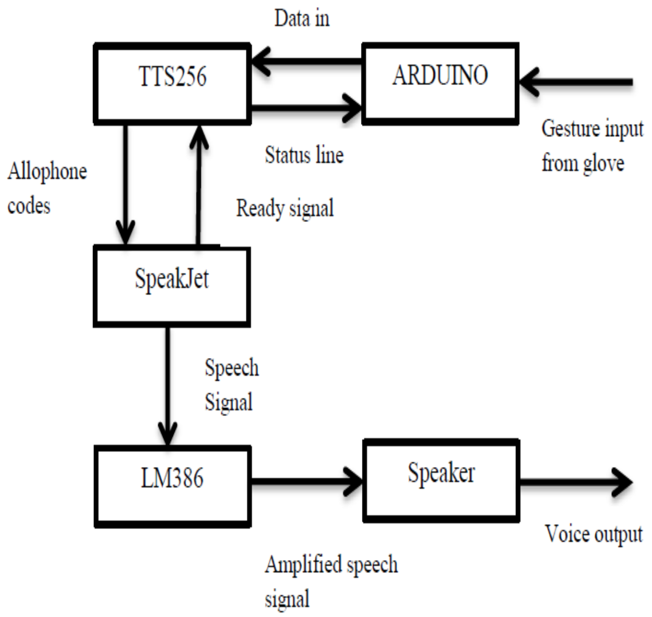


Figure 3. Block diagram of speech synthesizer

The technique behind TTS256 is that it accepts serial data ASCII characters and translates to syllabic sounds. SpeakJet generates an audio signal using five sine-synthesis generators for the allophones. A ready signal is sent from SpeakJet to TTS to indicate its ready state. The output from SpeakJet is amplified usingLM386 audio amplifier. The voice output is through a speaker.

III. RESULTS AND DISCUSSIONS

The evaluation of Deaf-mute communication interpreter was carried out for ten beginners for letters 'A' 'B' 'C' 'D' 'F' 'I' 'L' 'O' 'M' 'N' 'T' 'S' 'W'. Word formation from letters is also performed using an end signal.

The hand glove is mounted with five flex sensor, an

accelerometer and tactile sensors. Table 1 shows the
Output voltage across a voltage divider network with constant resistance of 22Kohms, the digital value and the corresponding resistance for different bending angles of flex 2.5" mounted in thumb and pinky fingers.

TABLE 1: RESISTANCE AND CORRELATED BENDING – FLEX 2.5"

DEGREE	VOLTAGE (ANALOG)	DIGITAL	RESISTANCE (OHMS)
0	3.655	748	27200
10	3.725	764	29215.686
20	3.797	777	31585.366
30	3.866	791	34094.828
45	3.968	812	38483.412
60	4.071	833	43842.105
75	4.174	854	50532.544
90	4.276	875	59121.622

The value of resistance increases with increase in degree of bending as in figure 4 and the output voltage of the voltage divider network also increases with increase in resistance as in figure 5.

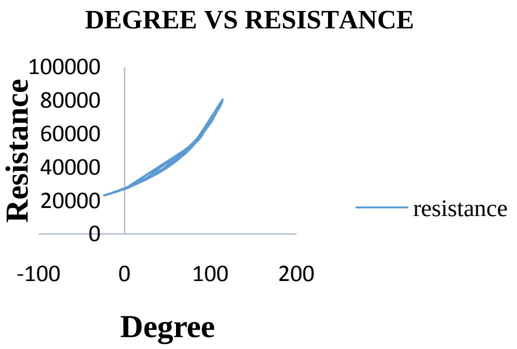


Figure 4: Plot of degree vs. resistance of flex 2.5"

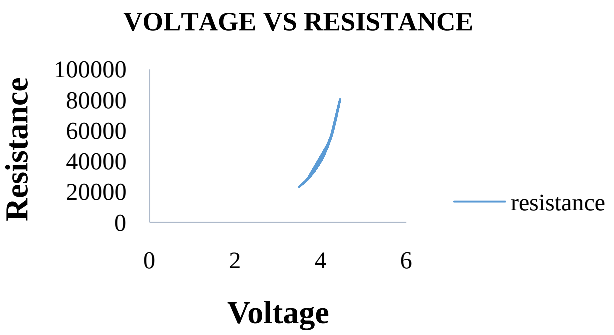


Figure 5: Plot of voltage vs. resistance of flex 2.5"

Table 2 shows the output voltage across a voltage divider network with constant resistance of 10Kohms, the digital value and the corresponding resistance for different bending angles of flex 4.5" mounted in index, middle and ring fingers.

TABLE 2 : RESISTANCE AND CORRELATED BENDING – FLEX 4.5"

DEGREE	VOLTAGE (ANALOG)	DIGITAL	RESISTANCE (OHMS)
0	1.720	350	11536.585
10	1.842	377	12832.172
20	1.955	400	14124.795
30	2.072	424	15572.618
45	2.250	462	18000
60	2.434	497	20686.277
75	2.624	534	24296.296
90	2.776	568	27460.432

The value of resistance increases with increase in degree of bending as in figure 6 and the output voltage of the voltage divider network also increases with increase in resistance as in figure 7.

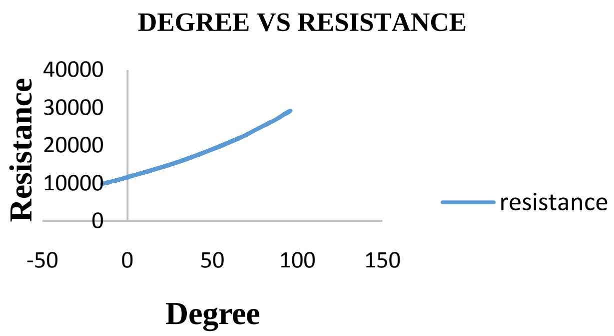


Figure 6: Plot of degree vs. resistance of flex 4.5"

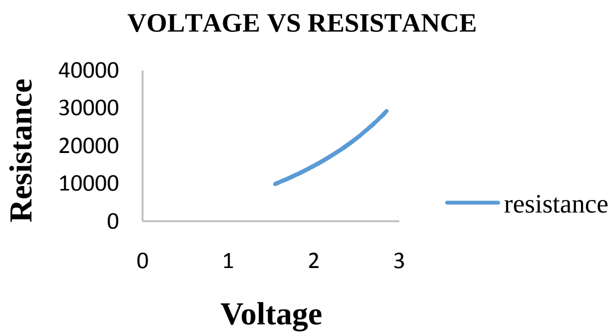


Figure 7: Plot of voltage vs. resistance of flex 4.5"

Figure 8 to Figure 15 shows the plot of gestures 'A' 'B' 'C' 'D' 'F' 'I' 'L' 'O' 'S' 'W' obtained using flex sensors with

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time along X-Axis and digital values along Y-Axis. The red line indicates the signal from thumb, green the signal from index finger, blue the signal from middle finger and black from pinky finger. Plot is observed to be unique for each gesture which is plotted using matlab software.

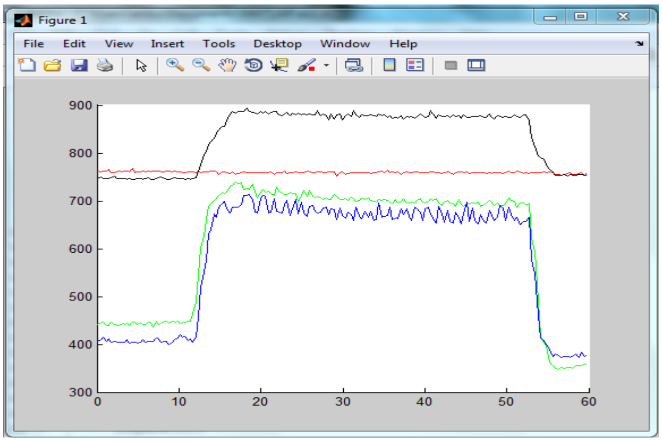


Figure 8. Plot of Gesture “A”

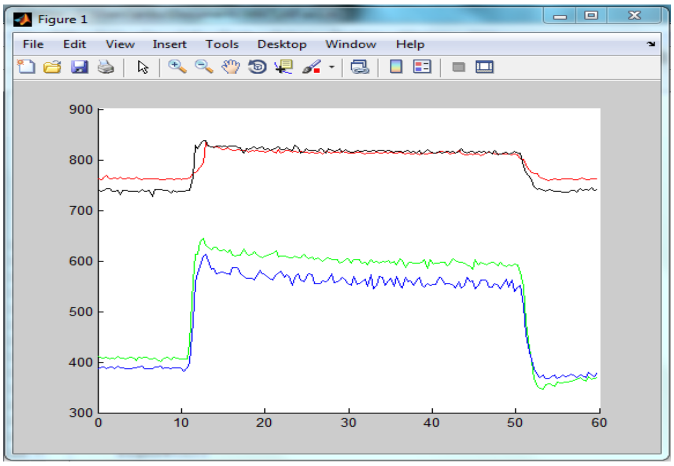


Figure 9. Plot of Gesture “C”

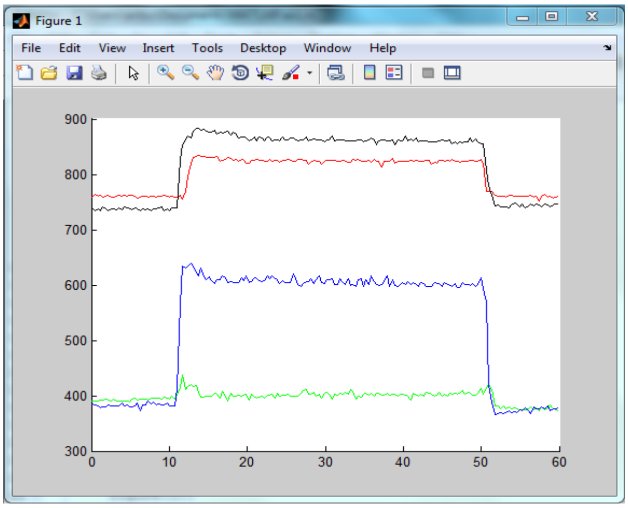


Figure 10. Plot of Gesture “D”

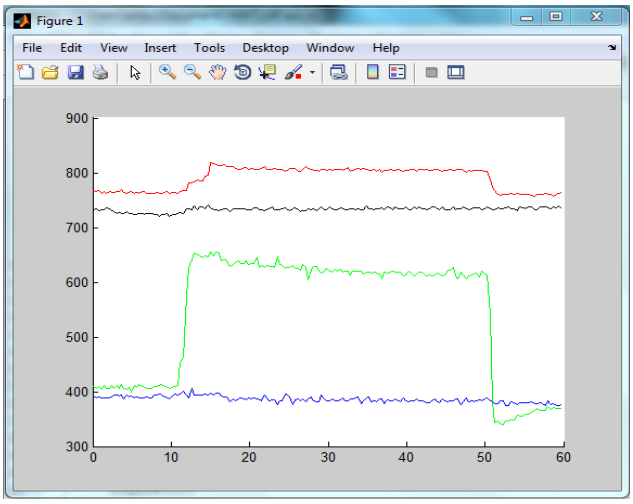


Figure 11. Plot of Gesture “F”

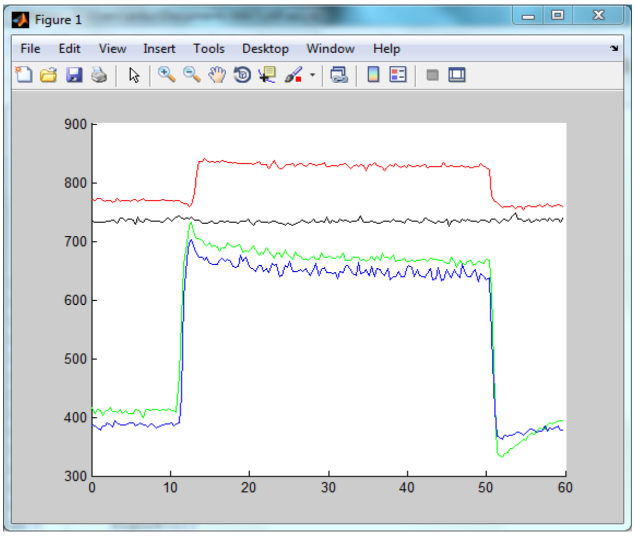


Figure 12. Plot of Gesture “I”

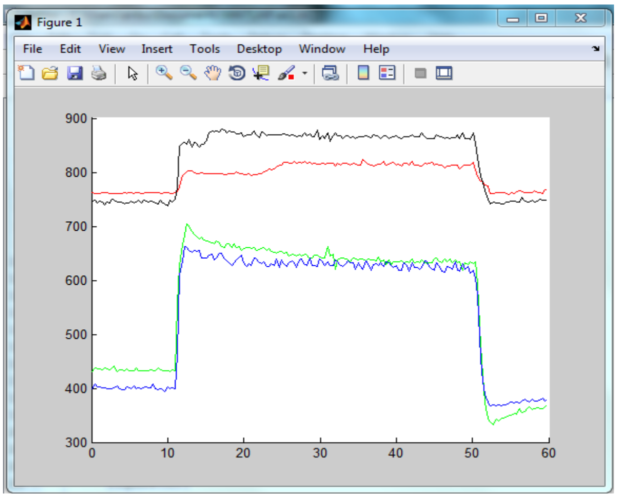


Figure 13. Plot of Gesture “O”

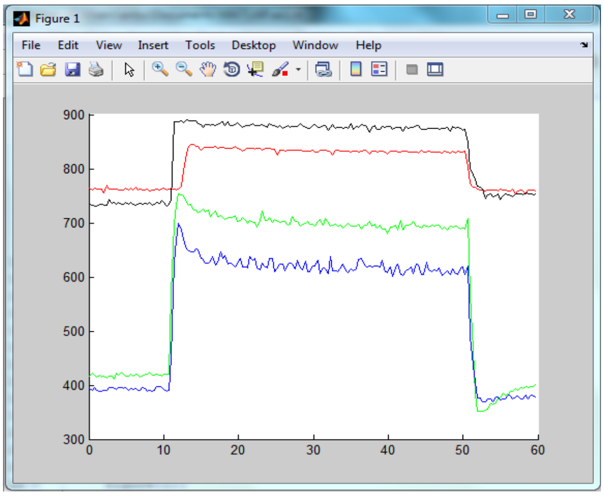


Figure 14. Plot of Gesture "S"

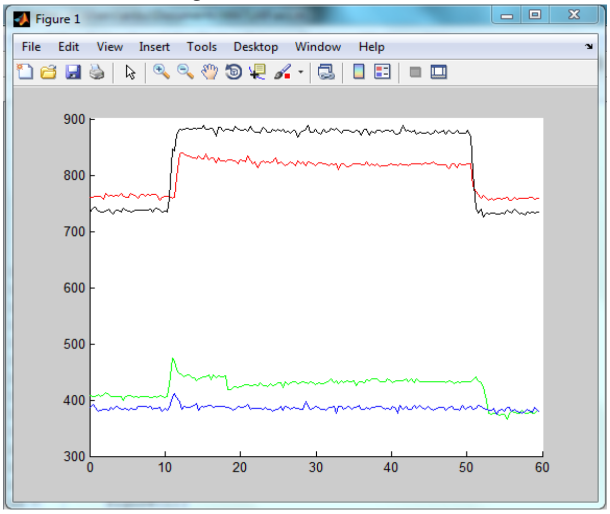


Figure 15. Plot of Gesture "W"

Table 3 to Table 5 shows the average value taken for ten persons from an accelerometer mounted in wrist for 27 gestures.

TABLE 3

	A	B	C	D	E	F	G	H	I
X	230	243	238	246	241	242	251	262	232
Y	314	308	304	307	308	300	355	364	300
Z	134	128	129	124	126	127	119	123	134

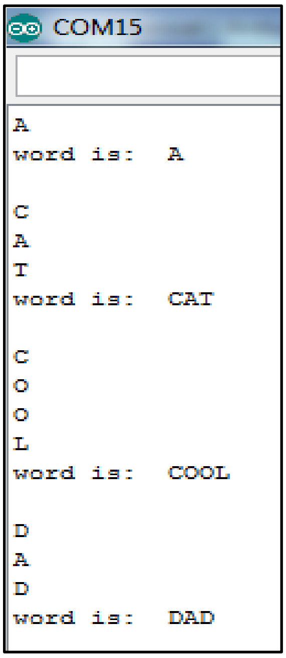
TABLE 4

	J	K	L	M	N	O	P	Q	R
X	232	231	239	229	227	237	259	257	236
Y	334	327	315	302	302	306	317	318	307
Z	134	136	127	130	135	129	118	115	130

TABLE 5

	S	T	U	V	W	X	Y	Z
X	234	227	242	240	243	243	246	244
Y	303	300	300	304	301	308	307	306
Z	130	135	127	127	127	125	125	126

The letters are concatenated to form words. The output from serial monitor of Arduino is depicted in figure 16 and 17.



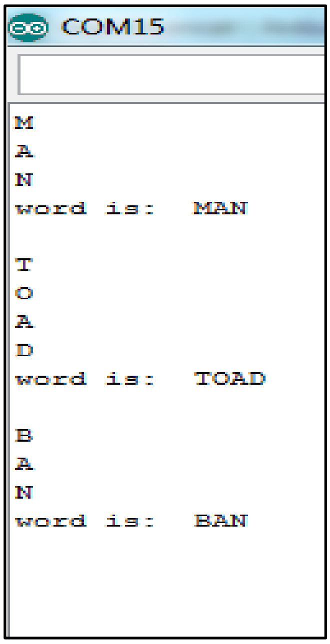


Figure 16: output of serial monitor Figure 17: Output of serial monitor

The device is also designed to input values of gestures automatically for each user by using training mode prior to the usage of device. LCD output of training mode and the digitalized voltage levels of flex sensor is shown in figure 18 and 20.

Figure 18: Training Mode "Gesture A"

Figure 19: Training Mode "Gesture C"

Figure 20: Training Mode "Gesture L"

The overall gesture recognition for the letters and words showed accuracy of about 90 percentage.

IV. CONCLUSION

The project proposes a translational device for deaf-mute people using glove technology. The proposed technique has enabled the placement of five flex sensor, 5 tactile sensors and an accelerometer on to a glove. The results demonstrate that sensor glove design with tactile sensor helps to reduce the ambiguity among gestures and shows improved accuracy. Further the device will be an apt tool for deaf-mute community to learn gesture and words easily.The project can be enhanced to include two or more accelerometer's to capture the orientation of hand movements once the gesture is made. This will expand the capability to translate larger gestures.

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