Development of a Smart IoT Enabled Arduino Glove Supporting Sign Language Communication

***Abstract*—Deafness is an unfortunate issue of our society impairing many people. Around 3 million people in Bangladesh suffer from partial or complete deafness. One key challenge for these individuals is communicating with regular people. Sign languages are available but very few people are acquainted with it. Keeping this issue in consideration this project has been developed. The smart Arduino glove will allow the user to express their ideas by translating their fingerspelling as well as the gestures into comprehensible messages. The system also allows identification of common sentences by identifying simple gestures. The suggested system if applied in daily life can cause a positive impact in the lives of deaf-mute individuals.**

***Index Terms*—Deaf, Mute, Sign language, Alphabets, Digits, Gesture Recognition, Flex sensor, MPU, Accelerometer, PAJ7620, I2C.**

I. Introduction

Congenital deafness can be caused by factors such as genetics, maternal infections such as rubella or cytomegalovirus (CMV), premature birth and other birth complications. Most deaf infants are in fact born to parents with no hearing impairment [1][2].

Sign languages are the most common option for deaf individuals as well as people hard of hearing or with oral conditions to communicate. These languages use visual keys as well as hand movements for communication. But since they are not universally understood it causes manifold issues in terms of conveying their message to other people and vice versa [3].

This project aims to try and improve the communication abilities of hearing-impaired people. An Arduino based system attached to a glove will be developed which will be able to comprehend the finger positions and hand gestures of the wearer and match them with specific texts relevant to sign languages. Additional features will also be added to convey or receive the text through blue-tooth from or to other devices and also alerting the wearer of loud noises in their location.

The contents of this report can be summarized in this way; after introducing the topic and discussing the validity of it in this part the literature review section will discuss the recent research and works done relevant to our project and the gaps and scopes for their improvement and optimization, the methodology will discuss the modules and working procedure of our system in enhancing sign language communication, the results and discussion section will demonstrate the various scenarios and results of communication through our system with some key notes, the section after this will discuss the limitations and future endeavors the conclusion will end the report discussing the degree to which the project goals were met, limitations of the project and future endeavors.

II. Literature Review

In recent times many commendable works have been done relevant to our project. In [4] a simple system has been developed which reads data from flex sensors attached to each finger over a glove and trigger certain pre-recorded audio based on certain finger combinations. This work has a lot of room for improvement since hand movement-based gestures are common in sign language and accelerometers can be added to improve the recognition of text.

The works done in [5], [6] and [7] improves upon this by adding an accelerometer to recognize hand gestures and a Bluetooth module to convey the messages. They have also tried to translate known sign language gestures instead of random gestures.

Improvements can be made to these existing systems by generalizing the text formation process, adding scopes for two handed gesture recognition and a minimalistic sound detection system which will alert the wearer in case of a loud noise or being called by someone from a distance.

III. Methodology

The goal of this project is to develop a system which can identify fingerspelling by detecting the folding state of fingers, hand gestures by analyzing the acceleration values recorder through the accelerometer, identify double handed expressions using an integrated gesture recognizer, detect loud noises in the environment using a voltage comparator-based sound sensor and finally a blue-tooth module to convey the texts to nearby devices. The following images demonstrate our project components:

Fig. 1. Flex Sensor

The flex sensor is capable of measuring the amount of bend or defection applied on to it. It contains electro-conductive material inside which goes through a change in resistance when bent. Each of the five fingers will have a flex sensor attached to it which will help to ascertain their position and bend information to the Arduino board.

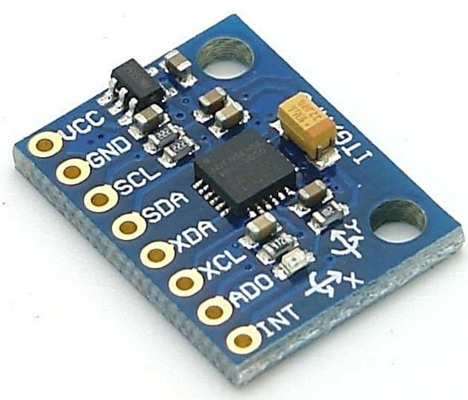

Fig. 2. MPU-6050 Accelerometer and Gyroscope

The MPU-6050 is an I2C motion processing unit capable of working as an accelerometer and gyroscope supporting measurements in 3 axes. It is categorized as a Micro Electro-Mechanical System (MEMS). It can measure linear acceleration as well gyration along roll, pitch and yaw axes respectively. In our project this sensor will be fitted on the right wrist of the wearer and it will be used to recognize hand position, movement direction and types.

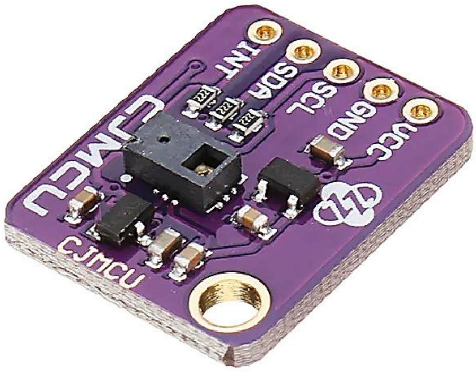

Fig. 3. PAJ7620 Integrated Gesture Recognizer

The PAJ7620 is an I2C integrated gesture recognizer, it performs minimal image analysis to identify the type of movement of objects in its vicinity. We shall fit it just below the right palm of the wearer and it will be used to identify the movement directions, that is up/down/right/left of the left hand in front of the right hand.

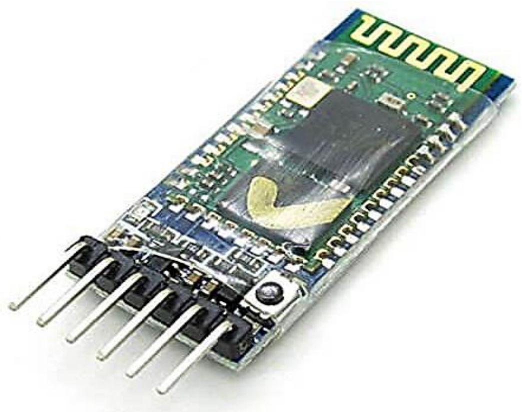

Fig. 4. HC-05 Bluetooth Module

The HC-05 is a 6-pin class-2 Bluetooth device supporting wireless serial communication. It has been categorized into class 2 due to having a maximum power of 2.5 mW and a working range of 10 meters. In our project its data mode has been used to connect to other Bluetooth devices and transfer messages to and from our smart Arduino glove.

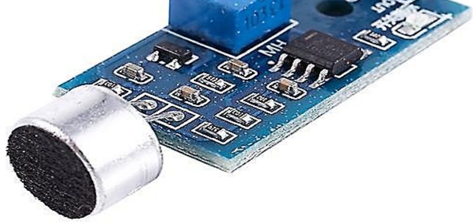

Fig. 5. LM393 Based Sound Sensor

The LM393 is an integrated circuit which mainly works as a voltage comparator. It is constructed in the Dual Independent Bus architecture, meaning it has two independent voltage comparators. The sound sensor made based on this IC takes in sound through a simple microphone and compares it to a threshold value which in our can be adjusted by adjusting the potentiometer attached to the module. For our project this device will work as an emergency detector. Whenever any loud noise would go off this module would identify that and buzz the vibrator attached to the glove, alerting the deaf wearer who otherwise wouldn't be able to sense it

Fig. 6. Simple Micro Vibrator

A simple micro vibrator will be attached to the glove, it will be used to alert the wearer in cases of message receivals through Bluetooth or instances of loud noises. For this project the micro vibrator we have chosen works on voltage around 3-5V.

Fig. 7. LCD Display with I2C Module

We have used a standard 16x2 LCD display for displaying the text translated from the hand expressions of the wearer. We have used an I2C module with the display to make the connections simpler by reducing from over 10 connections to only 4. A standalone LCD use parallel data bus but ones with the I2C module use a serial data bus.

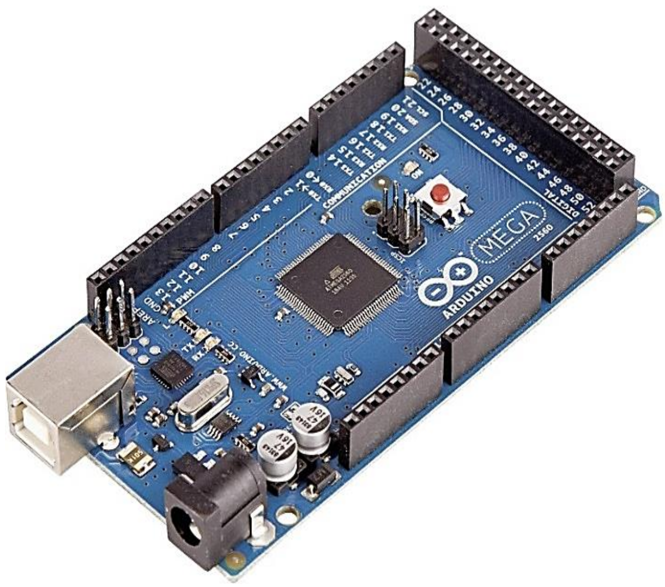

Fig. 8. Arduino Mega 2560 Microcontroller Board

Our glove will be powered by an Arduino Mega 2560 board. We have selected this board due to our project requiring a good number of I/O pins in which the Uno and Nano come up short. Other than this our project program is also fairly sizeable at 40 kb, so boards like Uno and Nano were not chosen. In addition to these comparisons, the Mega has higher clock speed, more flash memory and SRAM. Due to this we finalized using this board. Other generic products used in our project include a woolen glove, jumper wires, resistors, PCB boards, LEDs and a rechargeable 9V battery to power the system. On completing assembly our system looks like this:

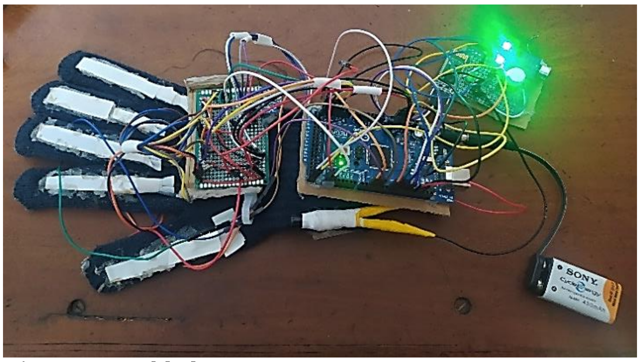

Fig. 9. Assembled Project.

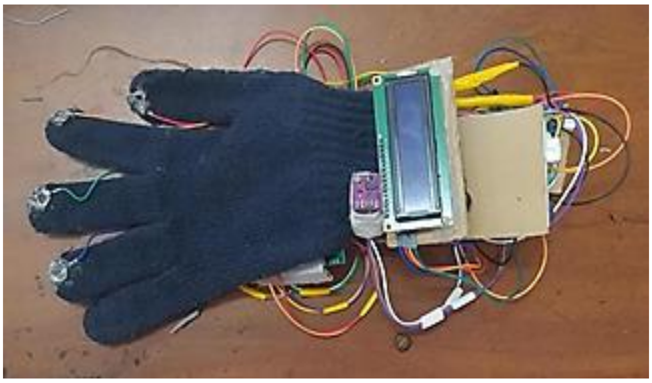

Fig. 10. Assembled Project (Palm Facing Upwards).

The following image shows the flowchart for our core project program.

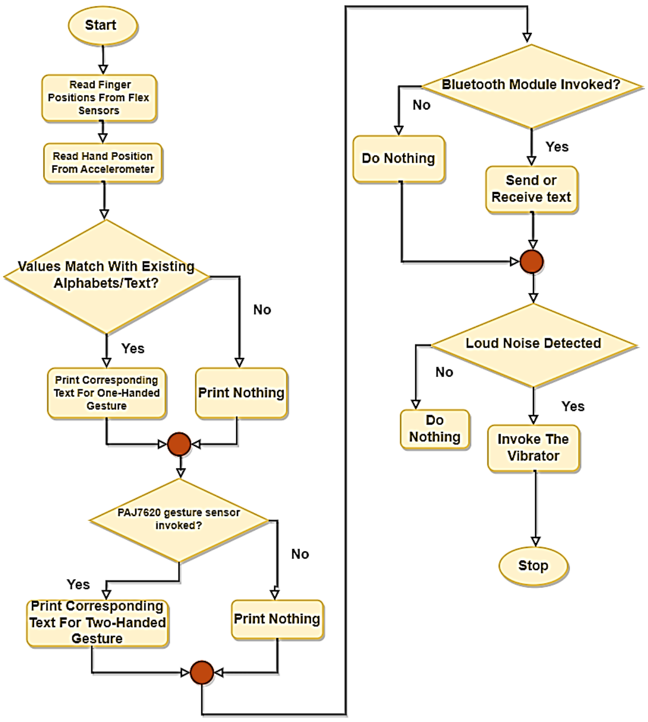

Fig. 11. Flowchart of the Project.

Our project program in simple terms will work as a continuously running loop after initializing all the necessary values and keep on reading values from the peripherals and analyzing and translating them into text or stimulus given to the user. Firstly, it will read the bend values of each finger through the flex sensors and also the hand- position from the MPU sensor.

Analyzing the various combinations the program will output various alphabets, digits and other characters to the display. After this it is up-to the wearer of the smart glove to express their message letter-to-letter and word-to-word with essential features such as spacebar and backspace included by specific finger gestures. After this the system will also look for left hand gestures pointed at the PAJ7620 sensor below the right palm and print them.

After this the program will also look for messages received through Bluetooth or loud noises sensed in the environment and notify the wearer accordingly. The noise sensing process will happen continuously alongside the delay function so as to immediately alert the wearer when a noise is sensed. The vibration will also be activated when a Bluetooth message is received by the system. This can easily be done using mobile Bluetooth interface applications. In instances of receival the messages will be shown in the display temporarily and the view will return to the original text inferred by the user in some time. Lastly it will look for the Bluetooth button input which would be pressed to transfer the text in the display to a connected Bluetooth device.

IV. Results And Discussion

The following images are part of a collection of a large set of images of finger-position combinations to represent each alphabet of the English language. It should be noted that many of the finger gestures have been modified from the common gestures of American Sign Language to ensure the simplicity of our project. The entire set can be accessed from the provided link at [8].

Fig. 12. Sample Sign Language Gestures for Alphabets.

The following images demonstrate the translation of these gestures into alphabets by our system.

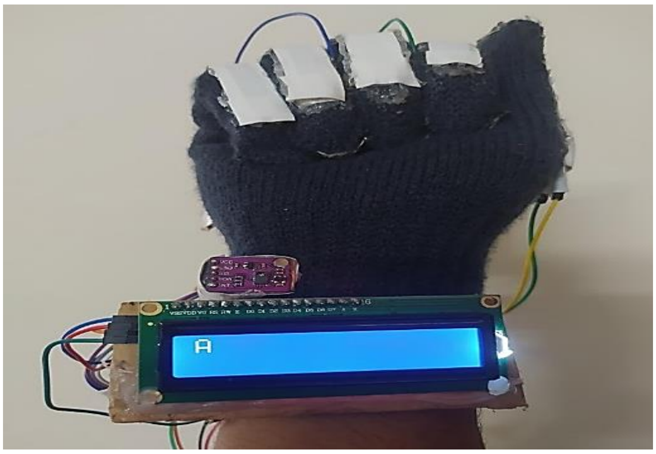

Fig. 13. Gesture to Alphabet Translation('A').

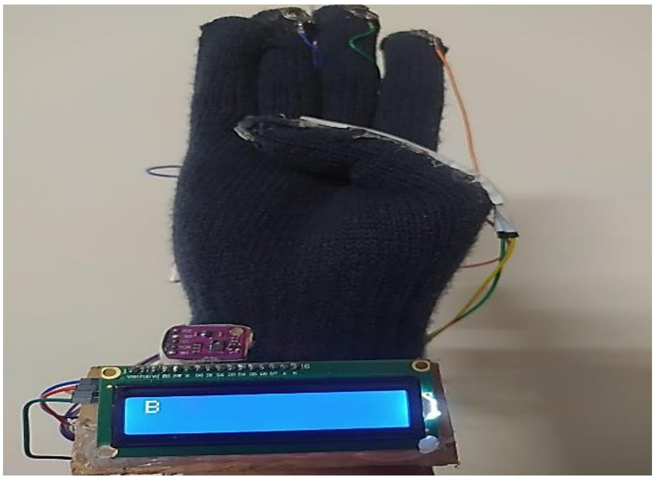

Fig. 14. Gesture to Alphabet Translation('B').

The following collage image demonstrates a word formation example, here we have fingerspelled the word 'Baby'.

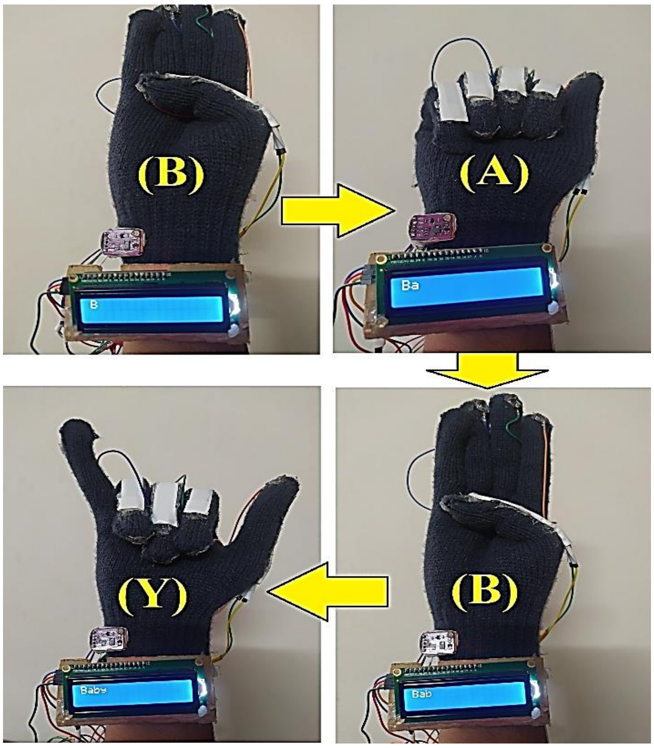

Fig. 15. Fingerspelling a Word Using Predefined Gestures.

The following images demonstrate the operation of two-handed gesture recognition.

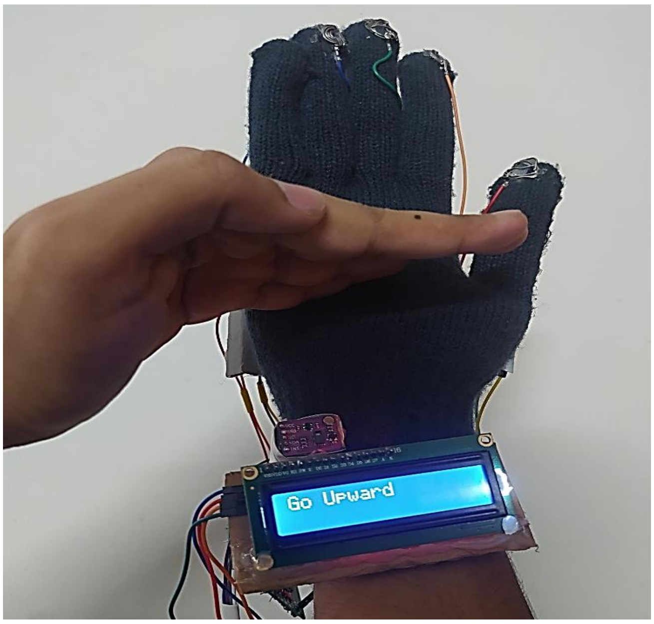

Fig. 16. Identifying Two-Handed Gestures (Up).

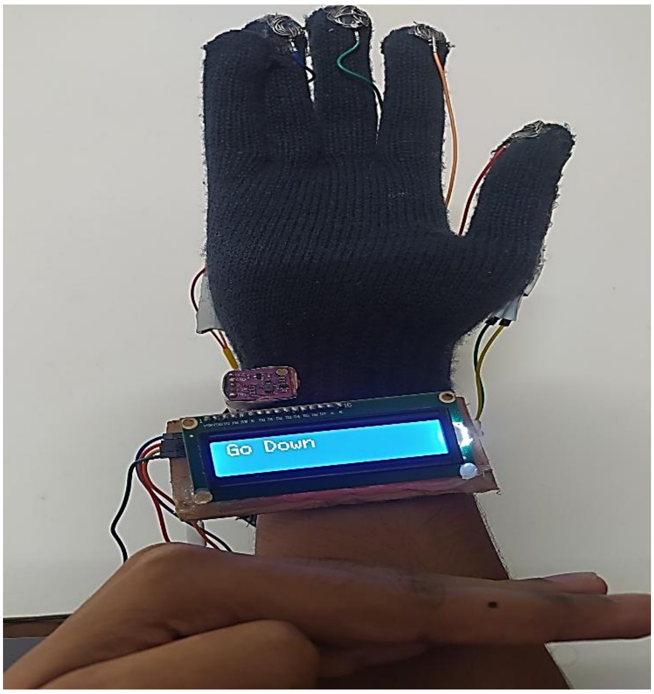

Fig. 17. Identifying Two-Handed Gestures (Down)

The following images demonstrate the operation of transferring the messages through the Bluetooth module.

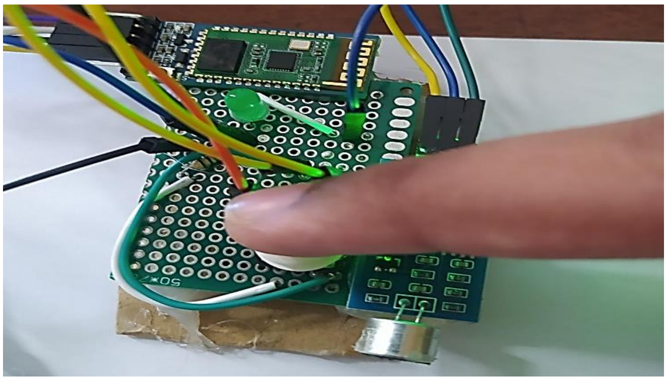

Fig. 18. Pressing the Bluetooth Button to Send the Message.

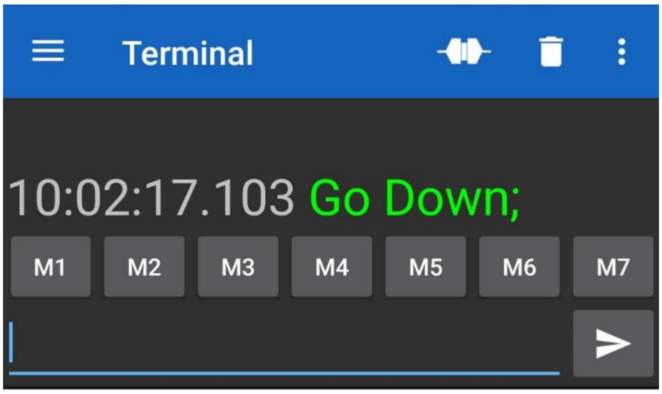

Fig. 19. Message Received (Serial Bluetooth Terminal App.)

The following images demonstrate the operation of receiving the messages from an android smartphone through the Bluetooth module.

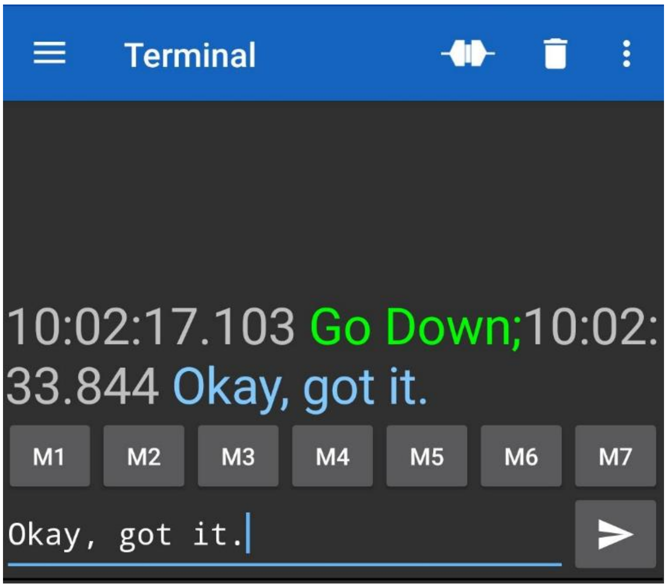

Fig. 20. Replying to the Message.

The system will notify the user that a message has been received through display and vibration.

Fig. 21. Notification on Receiving Reply

Fig. 22. Viewing the reply

The following images demonstrate the operation the sound sensor.

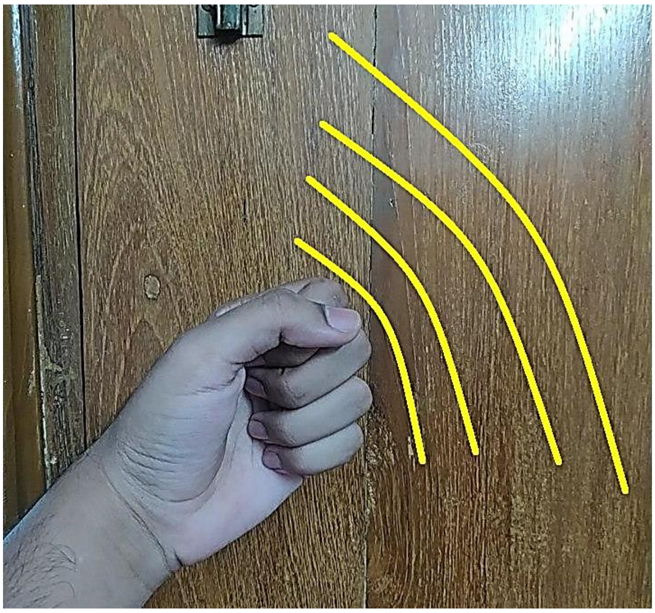

Fig. 23. Knocking on the Door to Make Noise

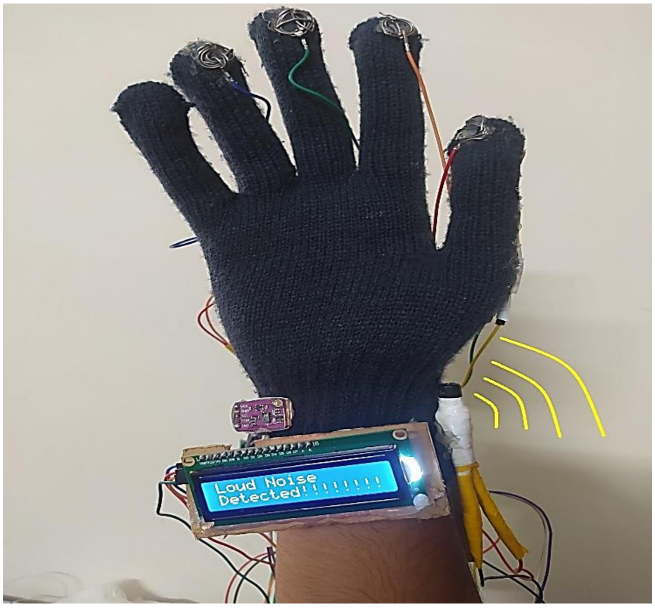

Fig. 24. Notifying after Identifying the Loud Noise

The following images demonstrate the simulation of fingerspelling alphabets in Tinkercad with some of the components replaced or removed due to availability issues of the software.

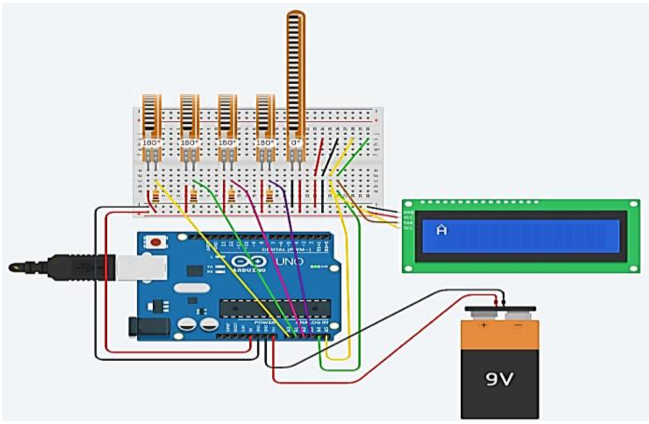

Fig. 25. Fingerspelling ‘A’ (Simulation)

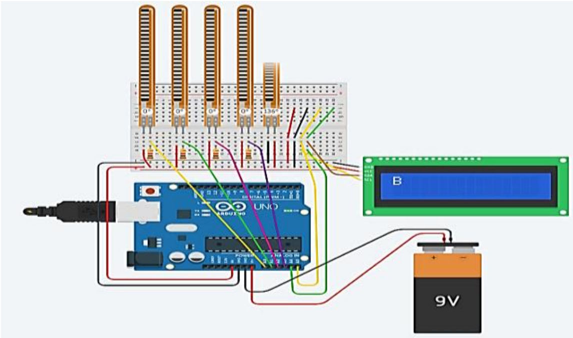

Fig. 26. Fingerspelling ‘B’ (Simulation)

V. Limitations and Future Endeavors

About the limitations of our project, it does have a fair few. For instance, the flex sensors are very sensitive and prone to damage. So, the system might become unreliable with repeated usage over time. Other than this the I2C bus of sensors can get mishandled if only one of them show transmission errors.

For future endeavors we would like to design the same project on a more powerful Raspberry Pi board so that we can employ Machine Learning techniques for better identification of characters from hand gestures instead of routing all the combinations manually.

VI. Conclusion

In conclusion, we can say that our project has been a success since it has successfully utilized the amalgamation of all the constituent sensors to create a system that can assist in the regular communication of deaf individuals. Our project provides key features which are capable of improving the social life of deaf individuals by fixing the communication gap between regular and sign language.

VII. References

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