Minia University

Faculty of Engineering

Mechatronics and
Industrial Robotics Program

Sign Language Translator (SLT)

A project submitted to the Mechatronics and Industrial Robotics Program as a partial fulfillment for the degree of B.Sc.

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CHAPTER ONE

Introduction

A crucial criterion for evaluating the civilization of nations and their growth is the standard of treatment of people with special needs. It is one of the aims of modern states and organizations. That derives from the legitimacy of the individual's right to equal opportunities in all aspects of life for a person with special needs and to live in dignity and equality.

In today's data-based world, connectivity is of utmost importance. shopping at a store, asking for instructions and directions, event planning, or even government agencies rely on communication. Without the opportunity to talk in order to express thoughts, regular activities such as dentist appointments or having dinner with a friend will be impossible for the average person.

For individuals living in a world deprived of sound. Sign language can demonstrate their points of view. However, not so many people are able to learn this language which creates a barrier between deaf people and the society. Our initiative is a hand gesture translator for deaf and mute people who interact with the world through sign language.

1.1 Problem statement

The everyday life of people with special needs in Egypt is devastating. Desperation and lack of hope for life are felt by almost every deaf and mute person. They live in isolation, and this adds to a socioeconomic inequality, because they believe like they are from another planet and that they have no right to exist and live in this society.

Out of all Egypt's population which is around 103 million, there are 7.5 million who are deaf-mute. On a wider scale, worldwide, there are 72 million of deaf-mute people. This makes it 10% of deaf-mute people in Egypt.

Sign Language is the technique in which deaf-mute people interact with others. Unfortunately, the number of deaf-mute people is inversely proportional with the number of people aware of sign language. Thus, deaf-mute people are desperately in need of a way to communicate easily with the world. A translator is needed to convert their language into text and voice, which people who do not understand sign language can readily understand.

1.2 Objectives

1.2.1 The main objective

Communication between members of society is one of the most important requirements of life, as the importance of communication lies in understanding others, transferring ideas and feelings, and exchanging information and experiences in all fields. That is why this project aims to make communication easier for the deaf and mute group with those around them.

It is a prototype that makes the deaf and mute group able to introduce themselves to other people, and it will facilitate the process of communicating with others, and thus this will make the deaf and mute more effective in society in general.

These gloves will help in translating sign language into spoken and written words on a screen and can also be heard out loud.

1.2.2 Supplementary objectives

In addition, it works to facilitate the communication of the deaf and mute group with the surrounding environment, as this project will support all the English alphabets and a set of words that the deaf and dumb may need to communicate with the surrounding environment.

It also aims to:

- Keep up with the rapid developments in this era, as everything is happening quickly.
- Make every member of society have importance and presence.
- Take advantage of all the skills, information and ideas inherent in every person who is difficult to express easily.
- Increase the presence of the deaf and dumb category in various sectors such as art, education, and employment.
- Finally, this project will become a reason to increase our expertise on many programming methods related to Embeds and Arduino.

1.3 Significance of the work

We have designed this model specifically for people from the deaf and dumb category in order to be one of the reasons that facilitate their communication with those around them. It can also be used to give live performances to an audience.

This glove could one day allow sign language speakers to communicate comfortably and at a cost.

In addition, it helps to spread the learning of sign language in the community, as the teacher can now teach his students the sign language in an easier and simpler manner than before, and thus this model has provided no small benefit in the field of education.

1.4 Project Outline (Methodology)

It consists of flex sensors on each finger, a gyroscope and accelerometer attached to the wrist that will detect the hand gestures and could be worn by a deaf-mute person, and an Arduinos. The detected hand gestures will be sent to an output peripheral such as a computer or a monitor thought out the Bluetooth module, then these detected gestures will be compared to previously stored data. After-that it will be converted into text on the display and speech throughout a speaker.

Hardware:

The following list contains the hardware components that we will be using in our project, it will be divided into two sections:

Detector:

This will be the part where all the detection and readings are from the various sensors and it contains:

Arduino Nano:

The Arduino Nano is a small, complete, and breadboard-friendly board based on the ATmega328 we will use it to control all the system sensors. This Arduino will detect the different hand gestures and placements. Also, it will compare the detected signals to the previously made database to get the exact word or letter needed to be displayed

Flex sensor :

It is a variable resistor; the resistance of the flex sensor increases as the body of the component bends. It has two available size:

- 2.2" (5.588cm) long.
- 4.5" (11.43cm) long.

We will use the longer one, because it is more reasonable to the average length of the fingers, and to get a more accurate reading.

MPU6050 3-axis accelerometer module:

It is a three-axis accelerometer sensor module based on MPU6050 integrated circuit. The ADXL345 is a triple axis accelerometer with extremely low noise and power consumption.

Both the gyroscope and the accelerometer will help us detect the exact position of each hand.

Translator:

This will be the part where all the received data are handled and programmed, and it contains:

Bluetooth module:

The detected readings from the flex sensors, gyroscope, and accelerometer will be sent throughout the Bluetooth module to the receiver side that will be up to the induvial user.

OLED:

An organic light-emitting diode (OLED), is a light-emitting diode (LED) in which the emissive electroluminescent layer is a film of organic compound that emits light in response to an electric current. It is a small display that will show the letters and words.

An OLED display was chosen over an LCD one because it is small and compact and will fit the glove perfectly.

Speaker:

It is an output peripheral that will emit the sound of the wanted word or letter that has been also displayed on the OLED.

Software:

We are going to use C programming language to program the Arduino and we will use this software for programming and simulation:

- Arduino IDE.
- Protues for simulation.
- EAGLE for PCB design.

The software part will be where all the hidden work actually is. We will have to make the drivers for the gyroscope, accelerometer, OLED, and speakers. We also will make a database for all the alphabets and most of the common words, and this is where all the work will be because there are no resources for this kind of data. Then we will initialize the system, take the readings compare it and send the data. The following flow chart simplifies the work process.

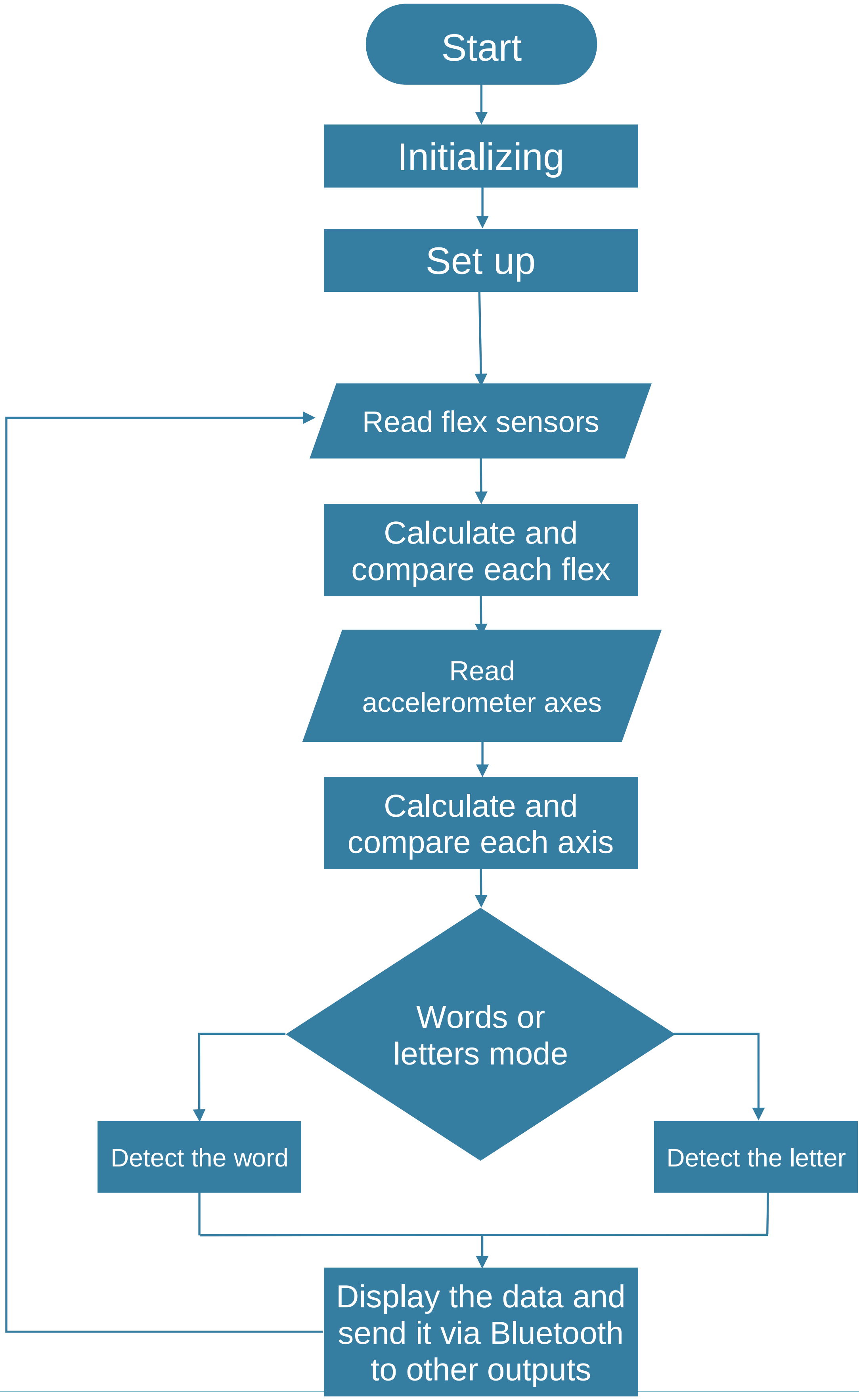

Figure [1]: Work Process flow chart

CHAPTER TWO

Literature Survey

These gloves are not a brand new idea, yet it is a cutting edge technology. This chapter is mainly about previous attempts of inventing a sign language translation gloves. It introduced the framework for the case study that comprises the main focus of the project.

Abdullah AL Mamun et al. [1] Sign language is the only way to communicate for listening and talking with disabled people. Approximately 10% of deaf people use sign language as their first language. We design a hand glove that will make the sign language understandable to all. An android mobile phone app is used to receive a voice which will convert it to speech and send it to the hand glove through wireless communication system. The result is shown on the LCD display of the glove. When the hand is moved, letter and word will be detected according to valid movement. As a consequence, the output will be displayed on mobile and LCD display.

Mohammed Elmahgiubi et al. [2] The mute/deaf individuals have a communication problem dealing with other people. It is hard for such individuals to express what they want to say since sign language is not understandable by everyone. This paper is to develop a Data Acquisition and Control (DAC) system that translates the sign language into text that can be read by anyone. This system is called Sign Language Translator and Gesture Recognition. We developed a smart glove that captures the gesture of the hand and interprets these gestures into readable text. This text can be sent wirelessly to a smart phone or shown in an embedded LCD display. It is evident from the experimental results that gestures can be captured by set of inexpensive sensors, which measure the positions and the orientation of the fingers. The current version of the system is able to interpret 20 out of 26 letters with a recognition accuracy of 96%.

Princesa Cloutier et al. [3] Communication between speakers and non-speakers of American Sign Language (ASL) can be problematic, inconvenient, and expensive. This project attempts to bridge the communication gap by designing a portable glove that captures the user's ASL gestures and outputs the translated text on a smartphone. The glove is equipped with flex sensors, contact sensors, and a gyroscope to measure the flexion of the fingers, the contact between fingers, and the rotation of the hand. The glove's Arduino UNO microcontroller analyzes the sensor readings to identify the gesture from a library of learned gestures. The Bluetooth module transmits the gesture to a smartphone. Using this device, one day speakers of ASL may be able to communicate with others in an affordable and convenient way.

The findings from this review reveal a lack of some crucial elements for the gadget to be available for everyone. Indeed, when consider together, it is clear that results of previous studies on sign language translating gloves are inconclusive in that they cannot regarded as robust or complete. Added to this, to date, no significant work has considered the affordability of the sign language translator, nor translating the whole alphabets.

The goal is focusing on the sign language translating gloves to be in the least price yet with a good quality, translating the whole alphabets to text and speech.

CHAPTER THREE

Proposed Design

The overall construct of the glove design was inspired by a list of necessities relevant to American Sign Language (ASL) users, the mechanics of American Sign Language, and the drawbacks of the related projects as mentioned within the previous chapter. These helped in developing three potential design methods for this project, which have been narrowed all the way down to one design. This architecture can be divided into three parts: motion or gesture sensing, signal processing, and data output subsystems Following that is a discussion of each of the subsystems, describing their position in the integrated architecture.

3.1 ASL User Requirements and Design Specifications

When interacting with the hearing world, deaf-born American Sign Language (ASL) users face a number of challenges. Adults who speak ASL are the most aware of these challenges, so requirements that they specifically state will take priority. These requirements will be considered later when determining product specifications.

A sign-language translating glove must meet a number of specifically mentioned requirements. These factors include the device's accuracy and speed of translation.

The average ASL user gestures around three signs per second, and although it is not mandatory for the system to match this pace during development, the quicker it can interpret as the user signs, the better. The glove's reliability is determined by this, as well as the glove's accuracy, including when and how frequently it will recognize and translate the right signal as the user signs it. The device's accuracy also includes its ability to incorporate the different gestures associated with ASL signs. This comprises not only palm and finger rotation and flexion, but also the hand's position in relation to the signer.

In addition, five device specifications have been identified, which improve the prototype's usefulness to ASL users. Several factors and relationships of the system with its users and surroundings were considered. The prerequisites are as follows:

1. Easy to Use
2. Portable
3. Affordable
4. Reliable
5. Aesthetically Pleasing

3.2 Design Selection

Taking in consideration the previous requirements and specifications, three concept prototype solutions were chosen, shown in the figures below:

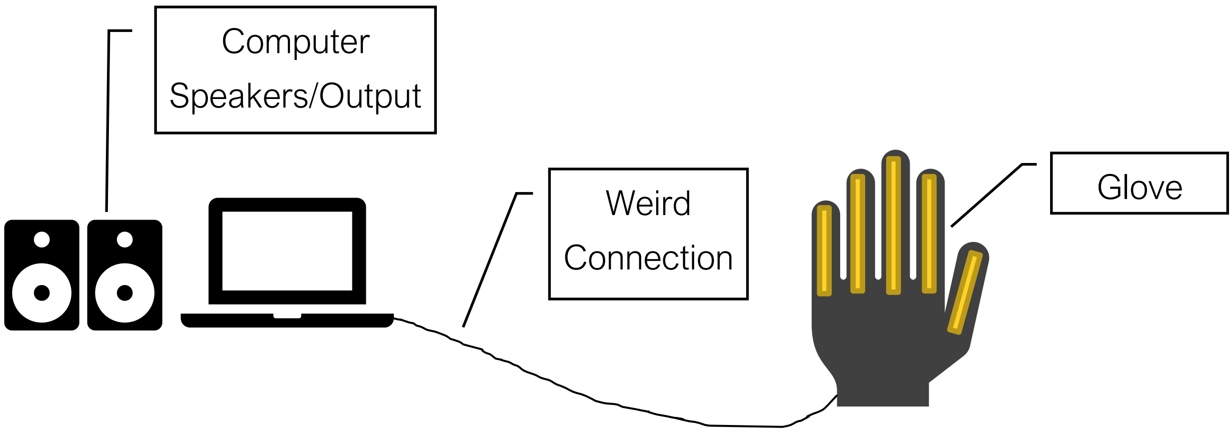

Figure [2]: Design 1

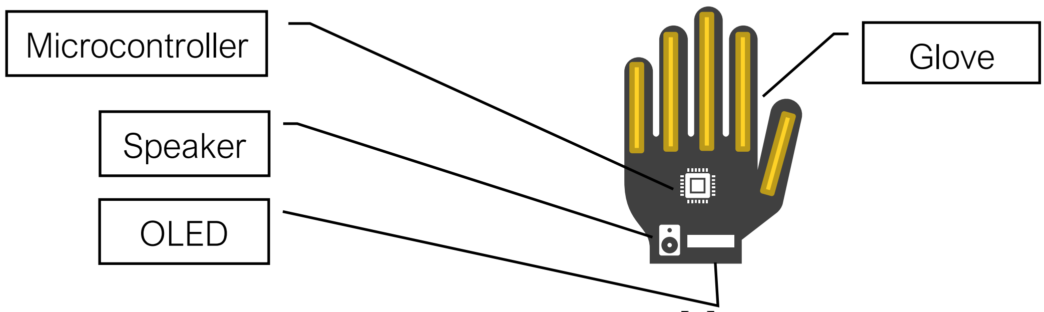

Figure [3]: Design 2

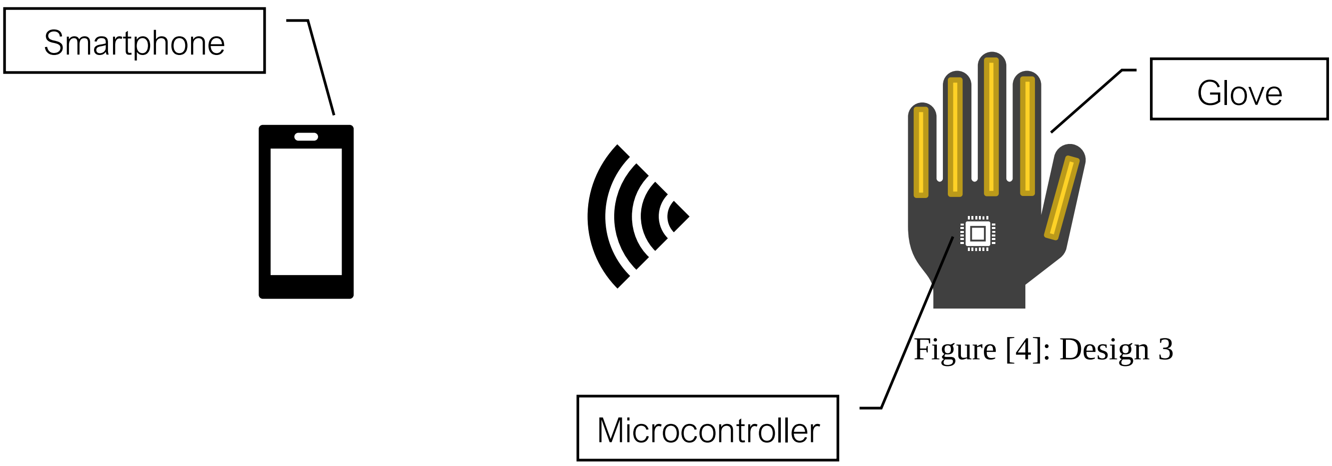

Figure [4]: Design 3

Design 1 includes a glove that is connected to a computer, which does all of the glove's processing and produces its own sound or other output. Design 2 is similar to Design 1 except that the processor is mounted on the glove as a small microcontroller and the output unit is a speaker that is also part of the glove, making this an all-in-one device. Design 3 is similar to Design 2, but it uses wireless communications to transmit sensor data to a smartphone (or other computing device), which then performs the processing and output functions.

Each of these design concepts has its own set of benefits and drawbacks. Design 1 has the least response time and the most durable of them all, yet it is also the least flexible and not aesthetically pleasing. Design 2 is the most flexible one and a whole package an all-in-one system. Design 3 has an upper hand in the output subsystem because it can easily transmit the translated text and speech to any device via Bluetooth.

In order to fulfill the previously mentioned requirements a forth design has been suggested, and it is a combination of both Design 2 and 3. This might seem odd or does not meet the affordability requirement, but in fact it’s not that expensive in comparison of what it can offer. It’s an easy to use device, portable because its an all-in-one, the most affordable that it can get, reliable at any time and place whether there is a smartphone or not, and above all it’s aesthetically pleasing.

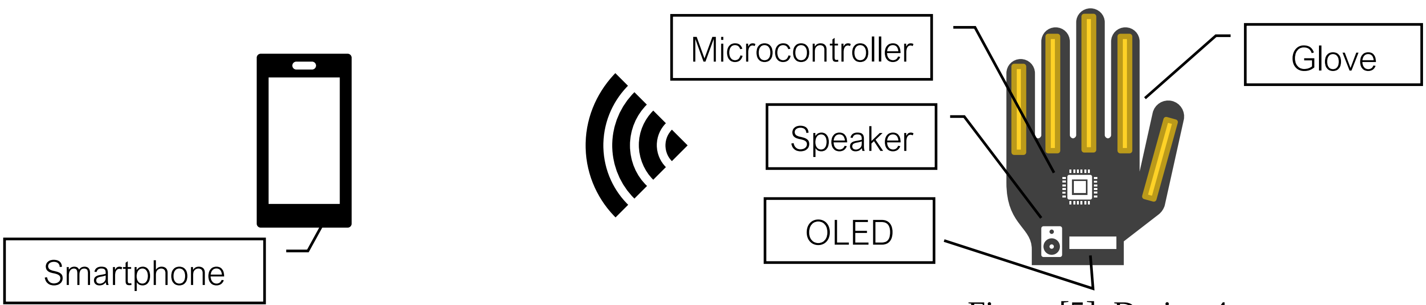

Figure [5]: Design 4

3.3 Material Selection

In the early stages, a glove made of wool was used, and some letters were extracted but with great difficulty, due to the complication of installing the sensors on the glove and keeping them fixed in their positions, which caused differences in the readings each time.

Later, a leather glove was put on test, but it did not work either, as the sensors were not fixed in place as desired, and there was a struggle in moving the hand and fingers due to the type of glove that does not match the type of devices installed on it.

A search for a glove of other materials was made, the aim was a material that can fasten the devices tightly, in addition of it being smooth and easy when wearing and moving the hand and fingers with no restrictions.

So, it was eventually reached to make a glove combined of two types of materials, one of which forms the basic structure of the glove, and this type of material is characterized by its high permeability of rubber that provides freedom of movement of the fingers and the hand without difficulty or discomfort in movement, and also to fit most people. This layer is covered by Bobbinet Tulle that was chosen because it is light and flexible, and it gives an aesthetic appearance to the glove. The sensors will be placed between these two layers.

3.4 Powering the Glove

To fulfil the requirement of making the glove portable and non-wired the glove had to be powered with batteries. Powering the glove went through many phases to choose the most fitting way. The First try was with 3 AAA batteries connected to a voltage regulator, but those won't last.

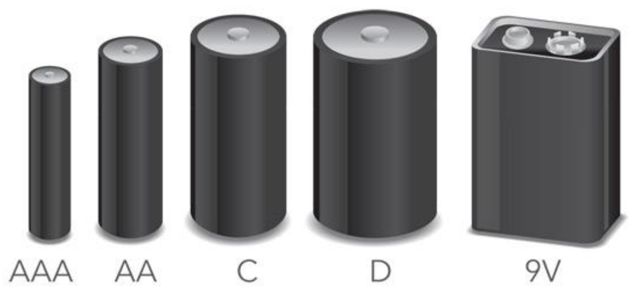

Figure [6]: Battery Types

The next phase was using a set of 3 AA batteries with a voltage regulator to power the glove.

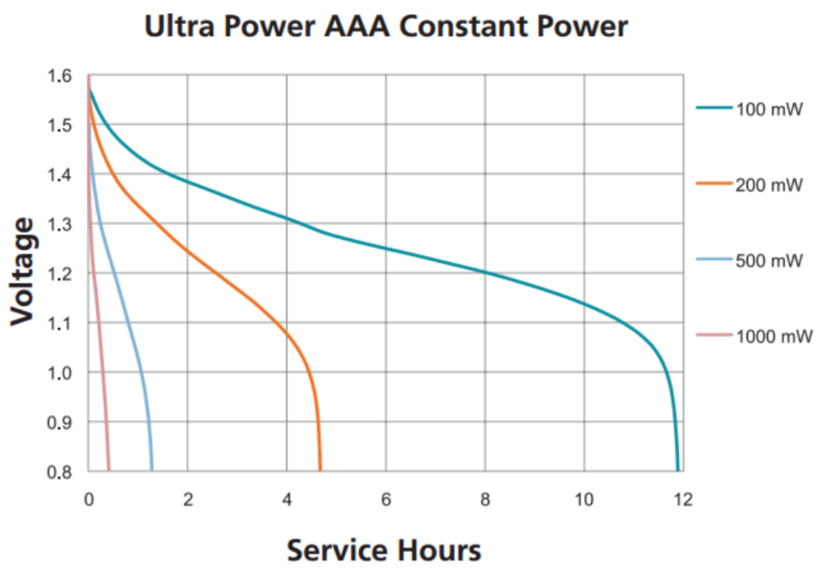

Figure [7]: This graph from Duracell's AA battery datasheet shows that at 118mW, the battery can last about 10 hours

According to the Duracell AA battery datasheet, the battery can output 100mW for 12 hours and 200mW for 5 hours (Figure 8). The battery life of the glove would be estimated to be around 10 hours based on the graph. This satisfies the criteria for through the day use. The glove may readily be worn for the most of the day by the user.

These numbers are undoubtedly great, yet the glove is supposed to be light weight, and reliable. Using AA or AAA batteries will absolutely be against both of these requirements. This is why a lithium ion battery was choosing to be the most suitable battery for this glove. It might be a little bit more expensive but being able to recharge it will be the best battery for long-term use.

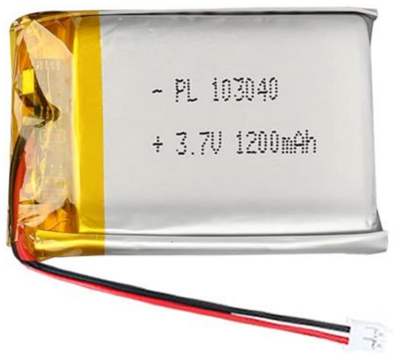

Figure [8]: 3.7V 1200mAh Li-Ion Battery

3.5 PCB Design

The glove was connected and tested thought out a breadboard, it was convenient, easy to change components and checking errors. But it is not convenient to be attached to the glove because it's huge and not flexible.

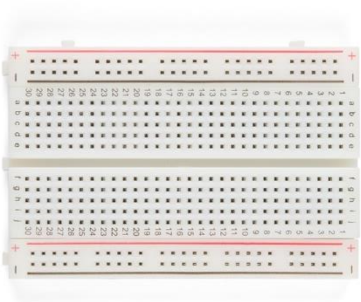

Figure [9]: breadboard

An organized schematic was made to keep track with all the connections, components, and signal flow.

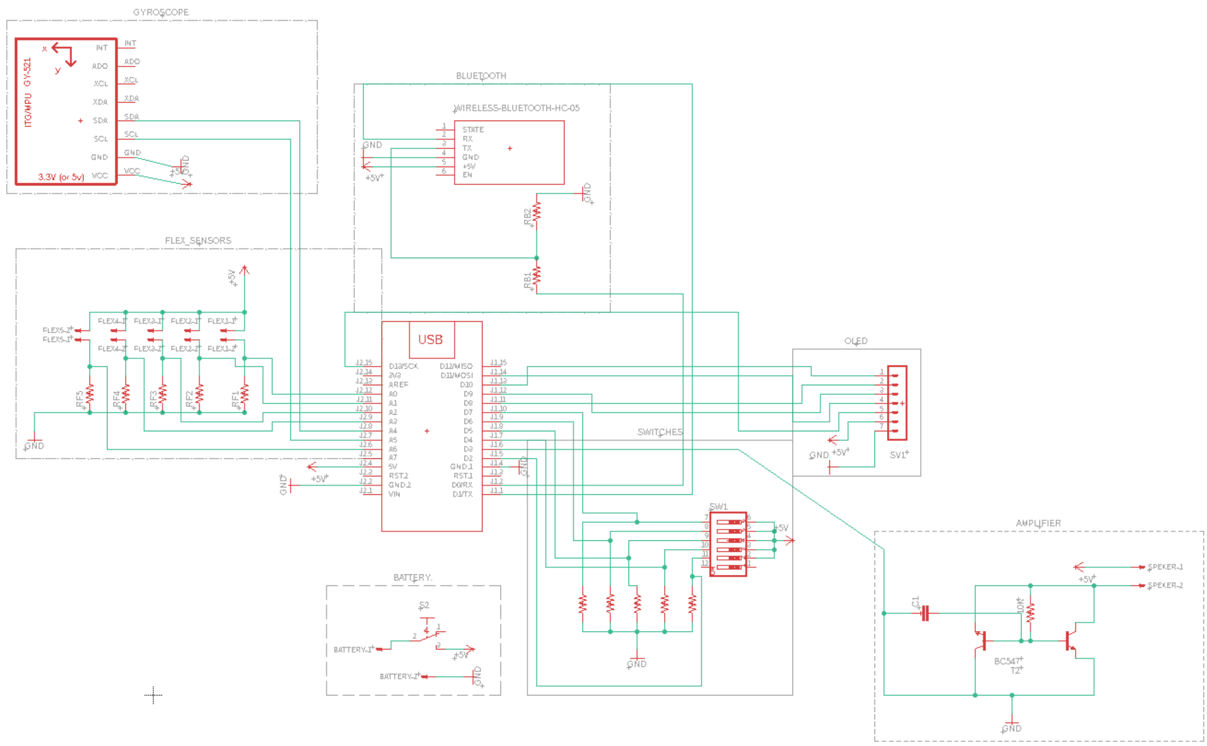

Figure [10]: Circuit Schematic

All the connections and components were gathered and connected on a dot board (Figure 11). The dot board has a little more false tolerance for changing a component are a connection.

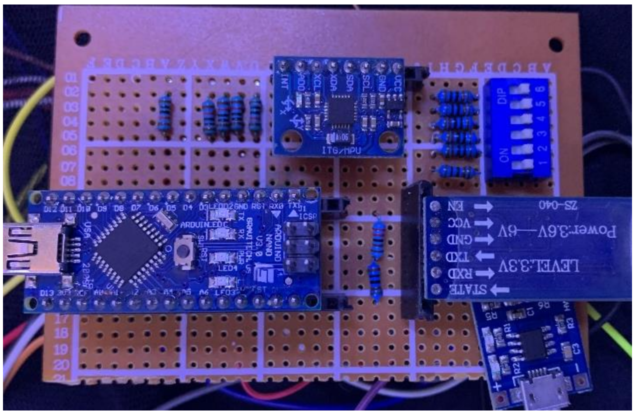

Figure [11]: Dot Board

To maintain electrical wires and components, embedded components, and microprocessor in a compact space, A PCB (Printed Circuit Board) was designed with the right dimensions to hold all the components and to be compact in size to be attached to the glove.

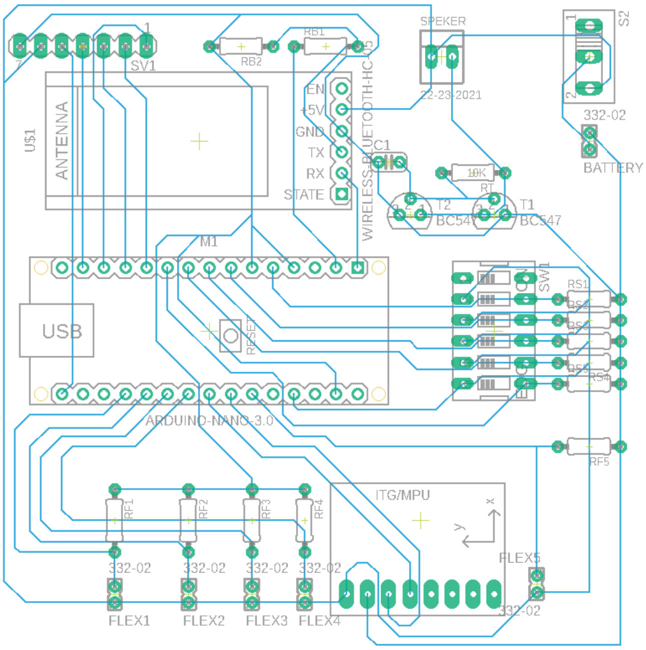

Figure [12]: PCB

CHAPTER FOUR

Results and Conclusion

Various types of challenges were encountered during this project. Attempts have been made to reduce the severity of the problems. Since this was a prototype, the goal was to create a concept that could resolve or reduce the communication dilemma with the deaf and mute people.

4.1 Results:

After the glove's concept was done, it was put to the test to ensure that it fulfilled the initial design requirements and production goals. Preparatory requirements included ease of use, portability, affordability, reliability, and aesthetics (Chapter 3. Proposed Design). In the design of the glove, the production goals were pursued and achieved.

4.1.1 Ease of Use

When defining the user requirements for the glove's ease of use, the speed of translation and the ease with which correct translations can be obtained are taken into account. No code-starting steps or anything of this sort applied to initiate translations. The only requirement for initiating sign translation was that the glove be turned on by flipping the control switch to ON and then pairing a phone with its Bluetooth signal. This, along with the glove's ability to change moods with the press of a button, contributed to the glove's ease of use.

4.1.2 Portability

It was critical from the start of this project to ensure that the glove is portable, so that it could be used in real life scenarios where connecting to a computer would be more inconvenient for translating than actually hiring an interpreter, assuming that there is a computer available at all. Since it is wireless, self-powered, compact and lightweight, the glove can be considered portable. The final output device was achieved through Bluetooth to a Smartphone and a computer app, so there was no need to attach the glove to any cables because everything needed for sign translation and signal transmission was built into the glove itself. Since the glove is small and compact, it can be conveniently packed and carried by the user, making it indeed portable.

4.1.3 Affordability

Evaluating the glove's affordability demanded consulting the bill of materials and adding the costs of each part involved in the final glove's construction (see Figure 13).

Description	Quantity	Unit price	Cost
Flex sensor 4.5	4	EGP 410	**EGP 1,640**
Flex sensor 2.2	1	EGP 245	**EGP 245**
Arduino Nano	1	EGP 70	**EGP 70**
Bluetooth module	1	EGP 125	**EGP 125**
Speaker	1	EGP 100	**EGP 100**
OLED	1	EGP 275	**EGP 275**
MPU-6050 Gyroscope and Accelerometer	1	EGP 60	**EGP 60**
Gloves	1	EGP 100	**EGP 100**

Battery and Charger	1	EGP 135	**EGP 135**
Total			**EGP 2,750**

Figure [13]: Budget

In its current state, the glove costs roughly EGP 2,800 The PCBs are not included in this calculation. If this glove were to be sold on the market with a 10% profit margin, it could be priced at around EGP 3,000. However, after replacing the parts in favor of mass-production capability and assuming a glove redesign, the price of raw materials can be lowered to about EGP 600. Assuming a labor, supplies, distribution, and retail markup of 100 to 200 percent, the final price of the glove will not surpass EGP 1,200. As opposed to the amount of money and time it would take to find an interpreter in any given circumstance, this price is rational. Furthermore, the price of the glove is almost entirely in the martial, not in the revenue.

4.1.4 Reliability

The most critical quality specification that had to be followed in order for this glove to be completed was its reliability. Not only did the glove need to be able to output a translated sign somewhere, but it also needed to reliably interpret a sign correctly. The glove has the ability to be programmed wirelessly from a computer via Bluetooth 100% of the time. The glove was able to correctly translate all the numbers and letters in the English alphabet, then output the translated sign as text and speech to a smartphone and a computer app via

Bluetooth using this software, thereby fulfilling the reliability specification. (see Figure 14 & 15).

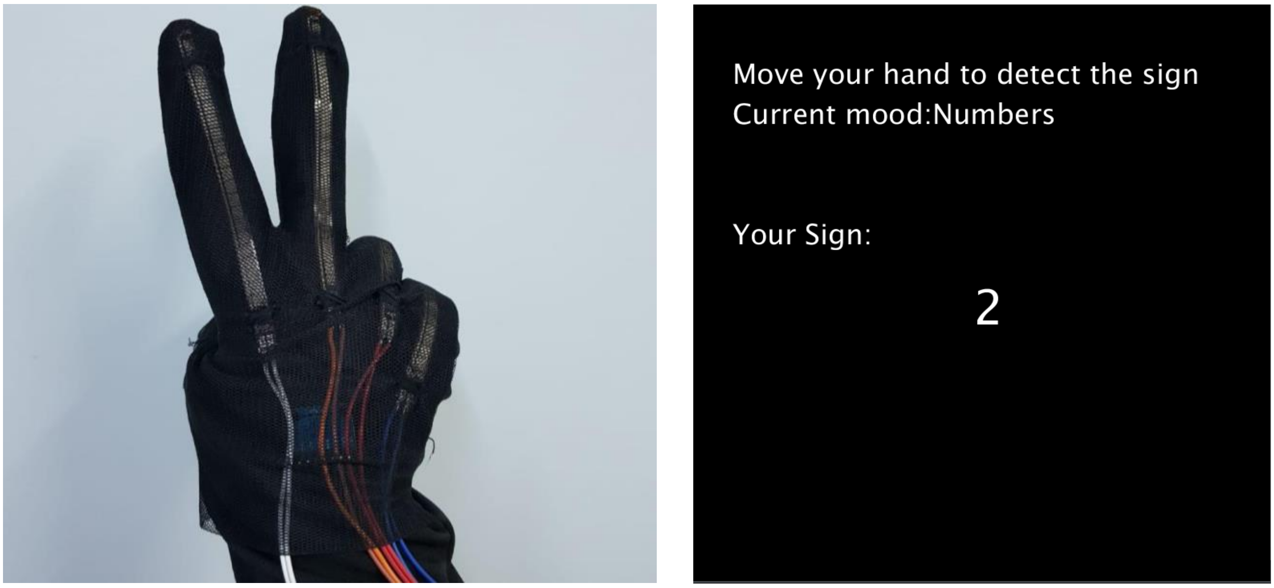

Figure [14]: Detecting the number 2

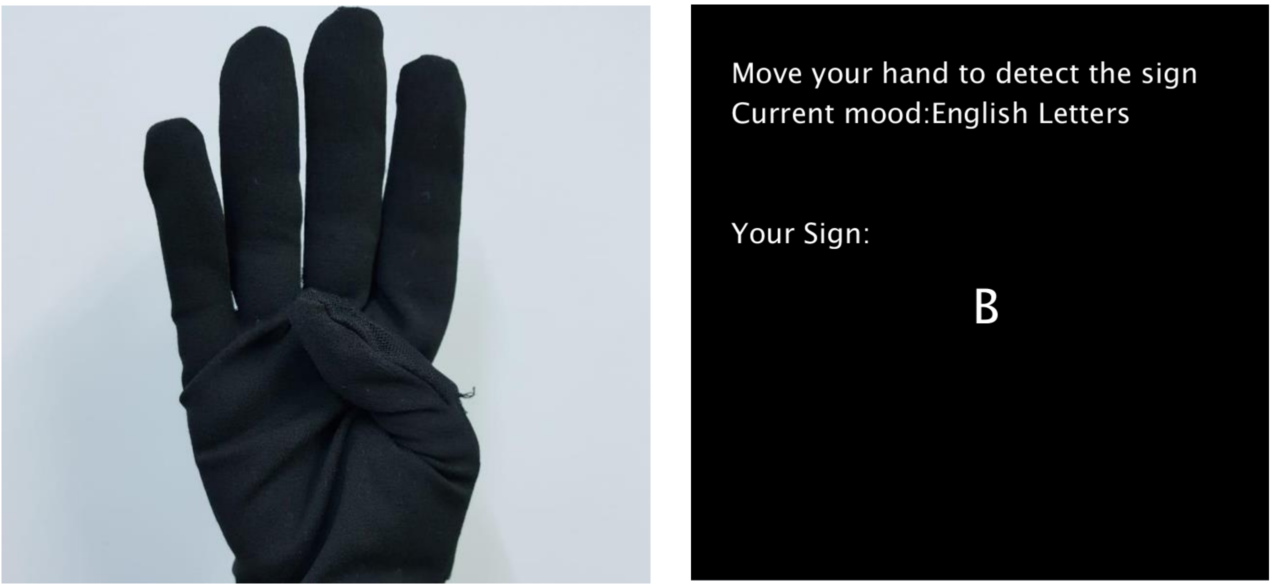

Figure [15]: Detecting the letter B

4.1.5 Aesthetics

If this glove were to become a market product, it would be preferable if it was aesthetically appealing so that customers would be more likely to buy it (see Figure 16). Ideally, it should match any other glove. Furthermore, the versatility of this glove contributes to its aesthetics. This indicates that it does not have any materials that obstruct the glove's mobility during extended use. In fact, since the glove is lightweight and easy to wear, it qualifies as wearable.

Figure [16]: The Glove

4.2 Drawbacks

All the letters of the English alphabet were successfully detected and translated, except for the letters “U” and “V”. That is due to the fact that the difference between the two letters in the sign language is very small. They are basically the same sign with a little gap between the fingers in V (see Figure 17). Therefore, it is impossible to distinguish between both of them with the used components in the glove.

An attempt has been taken to translate both of these letters with out the use of any additional hardware. By using the MPU6-6050 the letter “V” could be displayed if the hand is tilted a little bit to the left, making it possible to translate and display both of these letters correctly.

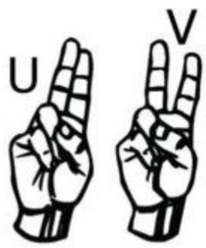

Figure [17]: “U” and “V” in ASL

4.3 Conclusion and Future work

Finally, the Smart Deaf-Mute Glove is a prototype that aims to improve communication for deaf-mute people. It is made up of two primary parts: a glove that detects hand motions and compressions and a translator that converts them into text and speech. The Smart Deaf-Mute Glove incorporates numbers, all the Arabic alphabets all English alphabets as well as a few Arabic and English words from which the user can compose a meaningful statement.

Essentially, what distinguishes this project is the technique that was developed and followed to construct it. Starting with a thorough examination of components in order to select those that provide the greatest outcomes and match the project's requirements.

In addition, the studying of the alphabets and coming up with a detecting algorithm for each letter. Furthermore, the scientific segmentation of flex sensor and accelerometer readings into zones enhances the project's scalability because these zones are a standard to which it may refer in order to implement new words.

The project was, however, constrained by the university's deadline and the restrictions of Covid-19, which hindered the flow of work. Fortunately, all of the objectives outlined in the original proposal were accomplish, and even a lot more than what was expected.

All the necessary hardware parts and software codes for this project are successfully made. However, more can be done to improve and enhance the device’s accuracy and reliability. It is simple to expand to two gloves for both hands and incorporate more ASL words and phrases that require two hands to be represented. This phase will not be difficult because the fundamental standard has been established to follow when implementing any new terms, but the time frame was the only obstacle.

Also, an application was made so that the translated sign could be displayed on varies outputs such as a computer, a display screen, or whatever the user prefers.

All the source codes will be in the Appendix for easier access to future development on the glove without the need to start from scratch. For reducing the price of the glove even more than that a preconstruction of the glove idea was that to replace the flex sensors for it being the most expensive hardware component with potentiometers. This will greatly reduce the price of the glove, but it will be much heavier, uglier, not reliable, and might fail a lot.

REFERENCES AND APPENDEIX

References

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[2] Sign Language Translator and Gesture Recognition - Mohamed Ennajar / Nabil Drawil / Mohamed Samir Elbuni - School of Engineering University of Guelph, Ontario, Canada / Computer Engineering, Faculty of Engineering University of Tripoli, Tripoli, Libya – 2015

[3] Prototyping a Portable, Affordable Sign Language Glove - Alex Hilderman / Regan Meheli - Faculty of Worcester Polytechnic Institute
Department of Electrical and Computer Engineering – 2016

[4] Smart Deaf-Mute Glove – Mana Lubbadeh / Aya Shashtari – Computer Engineering Department – An-Najah National University – Nablus. Palestine – 2017 – Figure 9 - Page 15

[5] Prototyping a Portable, Affordable Sign Language Glove – Princes Cloutier / Alex Helderman / Rigen Mehilli – Faculty of Worcester Polytechinic Institute – 2016

[6] Sign Language Translator and Gesture Recognition – Mohammed Elmahgiubi / Mohamed Ennajar – University of Guelph, Ontario, Canada – 2015

Appendix A: Code

Project_final Privet_defiens.h

```
/****************************************************************/
int thumb=0;
int index=1;
int mid=2;
int ring=3;
int pinky=4;
/***********************Thumb*****************************************************/
#define Fbind_thumb thumb_reading<=385
#define Hbind_thumb (thumb_reading>=390)&&(thumb_reading<=415)
#define Stright_thumb thumb_reading>=417
/*************************INDEX*****************************************************/
#define Fbind_index index_reading<=280
#define Hbind_index (index_reading>=290)&&(index_reading<=400)
#define Stright_index index_reading>=410
/*************************MID*******************************************************/
#define Fbind_mid mid_reading<=185
#define Hbind_mid (mid_reading>=190)&&(mid_reading<=290)
#define Stright_mid mid_reading>=300
/************************RING******************************************************/
#define Fbind_ring ring_reading<=210
#define Hbind_ring (ring_reading>=220)&&(ring_reading<=310)
#define Stright_ring ring_reading>=320
/*********************pinky*********************************************************/
#define Fbind_pinky pinky_reading<=250
#define Hbind_pinky (pinky_reading>=255)&&(pinky_reading<=390)
#define Stright_pinky pinky_reading>=395
```

Figure [18]: An h file that contains all the defines so that primary code is complicated

```
/*******************English Numbers*******************************************/
#define Zero     (Hbind_index)&&(Hbind_mid)&&(Hbind_ring)&&(Hbind_pinky)&&(Hbind_thumb)
#define One      (Stright_index)&&(Fbind_mid)&&(Fbind_ring)&&(Fbind_pinky)&&(Hbind_thumb)
#define Two      (Stright_index)&&(Stright_mid)&&(Fbind_ring)&&(Fbind_pinky)&&(Fbind_thumb)
#define Three    (Stright_index)&&(Stright_mid)&&(Fbind_ring)&&(Fbind_pinky)&&(Stright_thumb)
#define Four     (Stright_index)&&(Stright_mid)&&(Stright_ring)&&(Stright_pinky)&&(Fbind_thumb)
#define Five     (Stright_index)&&(Stright_mid)&&(Stright_ring)&&(Stright_pinky)&&(Stright_thumb)
#define Six      (Stright_index)&&(Stright_mid)&&(Stright_ring)&&(Fbind_pinky)&&(Fbind_thumb)
#define Seven    (Stright_index)&&(Stright_mid)&&(Fbind_ring)&&(Stright_pinky)&&(Fbind_thumb)
#define Eight    (Stright_index)&&(Fbind_mid)&&(Stright_ring)&&(Stright_pinky)&&(Fbind_thumb)
#define Nine     (Fbind_index)&&(Stright_mid)&&(Stright_ring)&&(Stright_pinky)&&(Fbind_thumb)
```

Figure [19]: Defining the numbers and letters

```
void loop ()
{

  thumb_reading = analogRead (thumb );
  index_reading = analogRead (index );
  mid_reading = analogRead (mid );
  ring_reading = analogRead (ring );
  pinky_reading = analogRead (pinky );

  //NUMBERS//

  if (Zero )
  {
    Serial.println (0);
  }

  else if (One ) {
    Serial.println (1);
  }
```

Figure [20]: The primary code that

```
void draw()
{
  /**** SERIAL PORT AVAILABILITY CHECK ****/
  while (mySerial.available() > 0)
  {
  myString = mySerial.readStringUntil(10);

  if (myString !=null)
    {
      myVal = myString;
      background(0);
      textSize(35);
      text("Move your hand to detect the sign", 50, 100);

    /**** NUMBERS CHECK ****/

     if (myVal.equals("0\n") == true)
      {
       text("Current mood:Numbers ",50, 150);
       text("Your Sign:",50, 200);
       textSize(50);
       text("1",345,345);
       Zero.play();
      }
     if (myVal.equals("1\n") == true)
      {
       text("Current mood:Numbers ",50, 150);
       text("Your Sign:",50, 200);
       textSize(50);
       text("1",345,345);
       One.play();
      }
```

Figure [21]: The primary code for the application

Appendix B: Sign Language

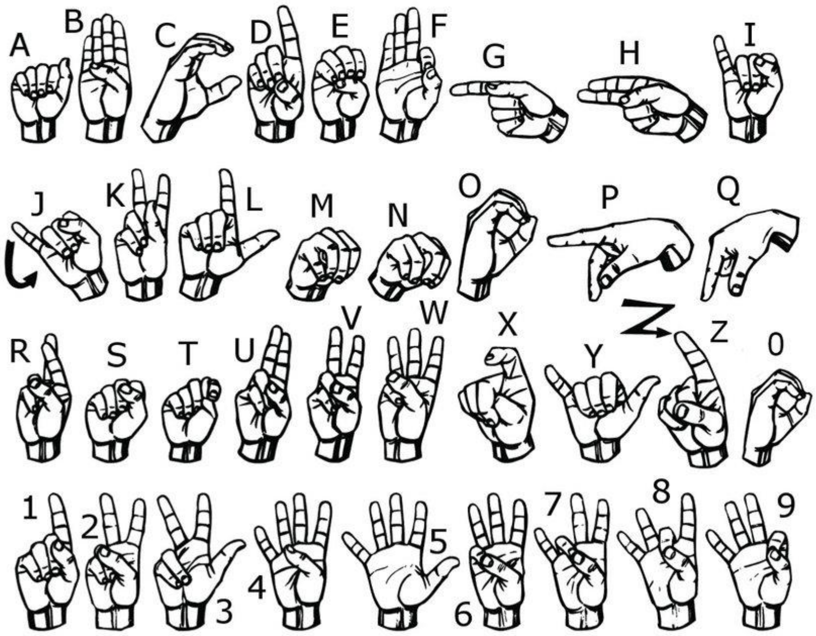

Figure [22]: ASL Alphabets

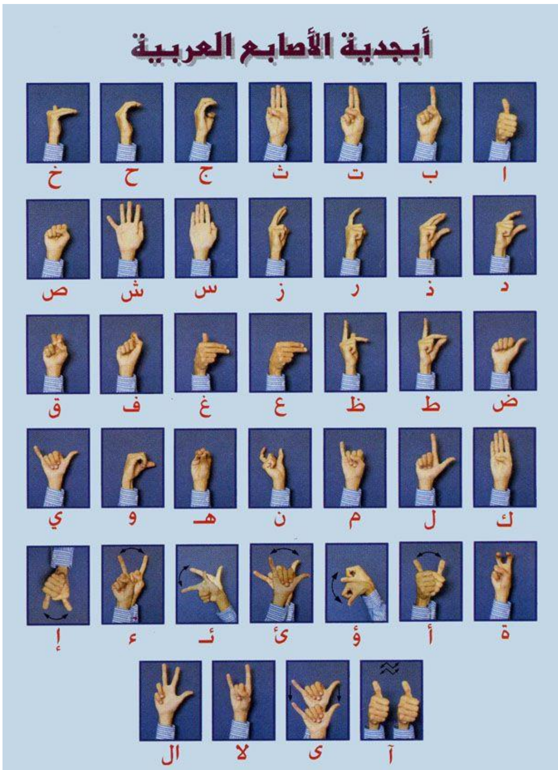

Figure [23]: Arabic Alphabets