Palestine Polytechnic University
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“ArSL speaking Gloves”

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Abstract

Mute people have trouble communicating with their surroundings, especially those who don’t know sign language, which makes them relatively isolated from their communities. In addition it's crucial for them to interact with others in order to live a normal life and hold jobs. This system is a development on a previous project that uses a right hand to translate letters and numbers from the Arabic sign language.

ArSL speaking gloves use a variety of sensors and other digital components to build an easy to use communicating system to establish a one way communication process between a mute person and people who don't know sign language. The system uses both right and left gloves that translates common words and sentences from the Arabic sign language into audible sound.The resulting gloves grants the person wearing it a full hand and fingers movement despite all the components attached to it, which will reduce translation mistakes. The implemented system succeeded to enable a mute person to establish a conversation with other people with success rate of 98.02%

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Chapter One

Introduction

1.1 Overview:

Muteness or mutism is defined as an absence of speech while conserving or maintaining the ability to hear the speech of others,[1]. The percentage of deaf and mute people in the world is 5%, and the highest rate in the Arab world is in Egypt , [2]. So, there is a lot of urging to find ways to help them in Arab societies. Most of mute people are facing difficulties when communicating with others because most people can’t understand sign language. This creates a need for human translation assistance which may disturb their confidence and privacy. From this standpoint, the idea of smart gloves came along. They enable the mute to be self independent when communicating with others.

1.2 Motivation:

The biggest motivation is to make mute people's lives easier than ever and boost their confidence when communicating with those who don't understand their sign language by implementing a technology that the latter understands easily (sound and text).
So the completion of the Arabic Sign Language speaking gloves(ArSLSG) will take them to the next level, which will be more efficient and more interactive.

There are also many incentives to do further work in this field:

1 - Many mute people suffer from difficulty in obtaining some jobs and opportunities due to their disability.

2 - When improving the gloves, they can be used as a practical tool for teaching sign language because words and sentences will be included.

1.3 Problem statement:

The mute people face a lot of difficulties where they need to interact with others who don't understand their sign language which makes the communication process between the two parties difficult and sometimes impossible. The previous glove that translates letters helps solving this dilemma but translating only letters seems not enough and in some situations inefficient. Therefore, the need for a more developed version of the talking gloves is a necessity to solve this problem by translating words and sentences of the ArSL of the mute people to an audible sound.

1.4 System Description:

The glove is a one way communication device that helps mute people to communicate with others who don't understand their language. This is accomplished by representing the Arabic sign language as an input from the sensors attached on the fingers and the hand palm, sending it to the Microcontroller; then converting it to an audible sound using a speaker, As shown in Figure 3.1.

1.5 Objectives:

We aim in our project to achieve several objectives:

1- Create a technology that will help the mute people to communicate with un-mute people by translating their arabic sign language to an audible sound.

2- Making gloves able to help them express their basic needs in their daily lives by implementing the necessary words and sentences in our system.

3- Making the gloves easy to use and efficient.
4- Reduce the error rate for the minimum.

1.6 list of requirements :

Functional Requirements:

The system should be able to perform the following functions:

1 - Gesture detection: the system must be able to extract the necessary information from the hand gestures using the sensors.

2 - Converting analog signals from sensors to digital data.

3 - Features Classification: the system must be able to classify the gesture features to words.

4 - Convert gesture to an audible sound using a speaker.

5 - Two modes of operation:

- Mode 1: the glove should give the user the ability to distinguish between a word mode or a sentence mode.
- Mode 2: when the system turns to sentence mode , the user has two choices of sentences (positive attitude or negative attitude) according to the situation.

Non-Functional requirements:

1- Accuracy: ensuring that the glove will have a high accuracy of gesture detection and classification to words and sentences, this is measured by observing low error rate.

2- Response time: ensuring that the system will have a high response time of gesture detection and classification to words and sentences.

3- Lightweight and Wearable: minimize hardware complications as much as possible.

4- Affordability: make the gloves cost efficient.

5- Safety: making the gloves safe and does not harm the user's hands in case of a hardware failure.

1.7 Expected results:

1. We expect to develop a system that will serve the mute people and help them to communicate with people who do not understand their language.
2. We expect the system to cover the basic and necessary words and sentences that a mute person needs in his daily life.
3. We expect the device to detect the movement of the hands and fingers of the mute person in an accurate manner. Then, it translates it into words and sentences in Arabic language and displays it as an audible sound with a suitable response time.
4. We expect our system to perform well, and fulfill our objectives.

1.8 Overview of the rest of report:

Next chapter, "background", contains the theoretical background and Literature review. Design options for hardware components, software and design constraints will be introduced too.Chapter three, includes a detailed conceptual description of the system, detailed design, schematic diagrams, block diagrams and structural diagrams.Chapter four,Implementation.Chapter five,testing and validation. Chapter six, conclusion and future work.

Chapter Two

Background

2.1 Overview:

In this chapter, we will review the theoretical background and the previous work and techniques that others used in their projects. It will provide the essential words that are being used by mute people in their daily lives.In the next sections the options of hardware components options will be shown and analysed.The final section introduces the design constraints of the system and any additional information for the reader.

2.2 Theoretical background:

1- the Palestenian Arabic Sign Language.

Sign languages are languages that use the visual-manual modality to convey meaning, expressed through manual articulations in combination with non-manual elements. Sign languages are not universal and they are not mutually intelligible with each other, although there are striking similarities among sign languages,[4].

The Arabic Sign Language (ArSL) is a natural language that has the same linguistic properties as spoken languages, with grammar that differs from Arabic. It is spread across the Middle East and expressed by movements of the hands and face. It is the primary language of the deaf and mute people. In addition to individual differences in expression, ArSL has regional accents, ArSL has regional variations in the rhythm of signing, pronunciation, slang, and signs used,[4]. In our project we are implementing the Palestanian Arabic Sign Language as our uniform language.

ArSL analysis:

We will categorize the Arabic Sign Language and analyze whether a category requires one hand or both, or if there is a need for other body parts, as shown in **table 2.1**.

Category	One or Two hands	Other body parts required	Implemented/ Not
Pronouns	One	No	Yes
Question Tools	Two	No	no
Family members	Two	Yes	Yes
Time	Two	No	no
Transports	Two	No	Yes
Body Parts	Two	Yes	no
Directions	Two	Yes	no
Health	Two	Yes	Yes
Places	Two	Yes	Yes
Home tools	Two	Yes	Yes
Food	Two	No	Yes
Verbs	Two	yes	yes
Adjectives	Two	Yes	no
Sentences	Two	Yes	Yes
Nature	Two	Yes	no
Cities	Two	Yes	no
Colors	Two	Yes	no
Electrical Tools	Two	Yes	yes
Drinks	Two	Yes	Yes
Jobs	Two	Yes	no

Table 2.1: Categories of Sign Language and Analysis .

Table 2.2 Lists the words and sentences that we have implemented in ArSLSG, we have implemented 37 words and 33 sentences.

Word	Sentence mode	
	Positive	Negative
انا	_	_
أنت	_	_
لي	_	_
لكم	_	_
لا	_	_
نعم	_	_
تكسي	_	_
باص	_	_
سيارة	_	_
نقود	أحتاج إلى النقود	لا أحتاج إلى نقود
طبيب	أريد الذهاب إلى الطبيب	لا أريد الذهاب إلى الطبيب
مريض	_	لست مريضا
دواء	احتاج إلى الدواء	لا أحتاج الدواء
كتاب	أريد الكتاب	لا أريد الكتاب
قلم	أريد أن أكتب	لا أريد الكتابة
بيت	أريد الذهاب إلى البيت	لا أريد الذهاب إلى البيت
مسجد	أريد الذهاب إلى المسجد	لا أريد الذهاب إلى المسجد
مدرسة	أريد الذهاب إلى المدرسة	لا أريد الذهاب إلى المدرسة
جامعة	أريد الذهاب إلى الجامعة	لا أريد الذهاب إلى الجامعة
سوق	أريد الذهاب إلى السوق	لا أريد الذهاب إلى السوق

مطبخ	أريد الذهاب إلى المطبخ	لا أريد الذهاب إلى المطبخ
حمام	أريد الذهاب إلى الحمام	لا أريد الذهاب للحمام
طعام	أريد أن آكل	لا أشعر بالجوع
ماء	اريد ان اشرب	لا أريد أن أشرب
انترنت	_	_
حاسوب	_	_
ملابس	أريد تغيير ملابسي	لا أريد تغيير ملابسي
السلام عليكم	_	عليكم السلام
شكرا	_	عفوا
مشكلة	هنالك مشكلة	لا يوجد مشكلة
أحضر	_	_
أعمل	_	_
أذهب \ أمشي	_	_
أريد	_	_
أخ	–	–
أخت	–	–
أم	–	–
أب	–	–

Table 2.2: the chosen words and sentences.

2- Features classification:

The features extracted from the sensors should be classified to result in a word or a sentence.

The main classification methods are:

- Static Tables: the features extracted could be compared within rows of features in a static table.

- Classifiers in machine learning: which are algorithms that automatically order or categorize data into one or more classes;(words/sentences) by utilizing some training data to understand how given input features relate to the class.When the classifier is trained accurately, it can be used to detect unknown data. Classification belongs to the category of supervised learning where the targets are also provided with the input data.

2.3 Literature Review:

Different techniques were developed over the years to ease the communication with mute people using sign languages. In general, the utilized techniques are classified to be either vision-based or glovebased [5, 6]. In vision-based technique: gestures are captured by a camera and then images features are extracted to interpret gestures' meaning. [7, 8]. In glove-based technique: the user wears a glove and through a set of sensors attached to it, gestures are translated into audio or text. [9,10]. Although vision-based techniques are more realistic, they require complex processes such as feature extraction and image processing. Moreover, the background and the position of the camera is crucial for the accuracy of the system, [6]. Unlike glove-based technique, it's characterized by a less computational complexity, fast response rate, and portability ,[6]. In general, both techniques are utilized to interpret the sign language in forms of isolated words or continuous words ,[5,11,12].

Various works were introduced under the umbrella of sign language translation , same are discussed in the following points :

1- In “Sign language to speech translation system using PIC microcontroller” [7], The authors presented a gestures translator system composed of 4 modules: sensing unit, processing unit, voice storage unit, and wireless communication unit, through a set of flex sensors and the gestures were processed by a PIC16F877Z microcontroller.

2- Based on a vision-based technique, continuous Arabic Sign Language (ArSL) recognition was introduced in “Continuous Arabic sign language recognition in user dependent mode” [5]. The system was developed using spatio-temporal feature extraction and Hidden Markov Models (HMM). The average recognition rate of words was 94%.

3- Another approach was adopted in “Glove-based continuous Arabic sign language recognition in user dependent mode” [9] to recognize continuous ArSL using two DG5-V hand data gloves. A digital camera was utilized to synchronize hand movement with words. Furthermore, word classification has been carried out by a Modified KNearest Neighbor (MKNN). This approach achieved a sentence recognition rate of 98.9%.
In a relevant study, isolated Arabic words were translated into sign language [11].

This table represents a comparison between different glove based projects from different aspects:

1- Smart Glove for Translating Arabic sign language [3]
2- gloves sign language translator [13]
3- sign language glove. [14]
4- “Smart deaf-mute glove [15]
5- Arabic Sign Language Translator (ARSL) [16]

#	Sensors Used	Classification method	Sign languages supported	# of Hands	Micro-Controller type	Translation level	One / two Way Comm -unication
1	Flex Accelerometer Pushbuttons	Static tables	Arabic	One	Arduino Nano	Letters	One
2	Flex HC Bluetooth MPU6050	Static tables	English	Two	Arduino nano	Letters and words	One

3	Accelerometer ADX335 Flex Sensor 4.5	Static tables	English	One	Lily pad Arduino	Letters	One
4	Flex, GY-61 DXL335 3-axis accelerometer, Contact pad	Static tables	English	One	Arduino uno	Letters and words	One
5	Flex Sensor Accelerometer	Decision Trees KNN (K-nearest neighbour)	Arabic	one	PIC18F642 0	Letters and words	One
6	ArSL Speaking Gloves	Static tables	Arabic	Two	Arduino Nano	Words and sentences	One

Table 2.3: comparison between previous glove based projects.

2.4 Design options and Specification:

Hardware Options:

A) Microcontroller :

The microcontroller is an essential part of the project because it is the data processing unit. Choosing the appropriate microcontroller was based on several characteristics, the most important of which are :
1 - speed
2 - the suitable size
3- Sufficient memory

As shown in **Table 2.4 ,** We have studied the possible options, compared them and chose the most suitable for our project .

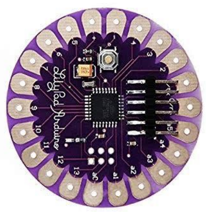
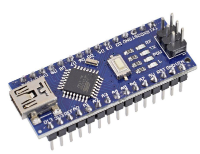
Microcontroller				
Type	Image	Advantages	Disadvantages	Chosen / not
Lily pad		1 -Low cost . 2 - Small size . 3 -Suitable to install on the gloves.	Slower than the other options	✗
ESP32		1 - builtin WiFi 2 - built in bluetooth module. 3 - small size 4 -suitable to install on the glove.	Higher cost	✗
Arduino nano		1 -Low cost . 2 - Small size . 3 -Suitable to install on the gloves. 4 - Functionally the same as their larger counterparts. 5 - fast .	Limited on board memory can make complex programs difficult.	✓

Table 2.4: List of Microcontroller options

Analysis: As shown in table 2.4, We chose Arduino nano because it's small and it’s faster than the lilypad, Nano has speed of 16MHz while lilypad speed is 8 MHz.

B) Communication:
The communication between the two gloves is necessary and must be real-time communication , there are many options in communication.Our choice was between Bluetooth module HC-05 and Wi-Fi , since the two gloves will be close to each other the bluetooth module is the better choice , as shown in **Table 2.5** .

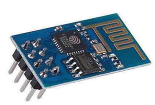
Communication				
Type	Image	Advantages	Disadvantages	Chosen / not
Bluetooth		1 - Low power consumption . 2 - small size . 3 - easy to use. 4 - low cost . 5 - suitable size.	1 - short range . 2 - slower .	✓
Wi-Fi		1 - Fast . 2 - long range. 3 - easy to use. 4 - secure . 5 - suitable size.	1 - High power consumption. 2 - expensive.	✗

Table 2.5: List of Communication options

Analysis : As shown in table 2.5, Our choice of bluetooth was based on its low power consumption, in this system we need power for the longest time possible .

C) Push buttons and Touch sensors :
Push buttons or touch sensors are necessary to perform some events like turn ON or OFF the system and switch to sentence mode. We had many choices and wanted to choose the most suitable for the glove and the simplest as well.

Push buttons and Touch sensor				
Type	Image	Advantages	Disadvantages	Chosen / not
Touch sensor		1 - easy to use. 2 - faster . 3 - suitable size.	1 - higher power consumption. 2 - higher cost . 3 - sensitive .	✗
Push button		1 - easy to use. 2 - suitable size.. 3 - lower cost . 4 - less power consumption.	The button suffers a lot of damage from repeated use	✓
Limit switch		1 - easy to use. 2 - low cost . 3 - less power consumption.	Thickness is not suitable.	✗
Force sensor		1 - suitable size. 2 - easy to use.	Higher cost	✗

Table 2.6: List of Push buttons and Touch sensor options

Analysis: As shown in table 2.6, push buttons are preferred in cases the user has to push on some part of the hand to control some events, But the touch sensor is preferred when a touch on a specific part needs to be recorded.

D) Accelerometer :

To detect the gesture we need to measure the acceleration of the hand gesture on the three axis (x,y,z) , there are many types of Accelerometers , we compared between the possible cochise and we found that MPU6050 is the propriate for the project because it combines between accelerometer and gyroscope which are needed in our project.
So for reducing the hardware complications choosing MPU6050 is the better choice.

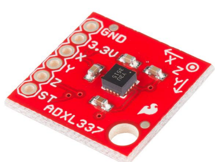
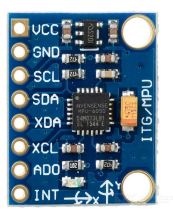
Accelerometer				
Type	Image	Advantages	Disadvantages	Chosen / not
ADXL335 Accelerometer		1 - lower cost . 2 - less power consumption . 3 - uses in the triple axis (x,y,z) 4 - suitable size .	It is sensitive to temperature and operates over a limited temperature range.	✗
ADXL337 Accelerometer		1 - uses in the triple axis (x,y,z) 2 - suitable size .	higher power consumption .	✗
MPU 6050		consists of three-axis accelerometer and three-axis gyroscope	It has only 6 degree of freedom while other gyro and accelerometer sensors has 9 and 10 degree of freedom	✓

Table 2.7: List of Accelerometer sensor options

Analysis: As shown in table 2.7, We chose mpu6050 Accelerometer and gyroscope because it has a lower cost, and it consumes less power than ADXL337. Additionally, it has a 6 degree of freedom containing a gyroscope.

E) Analog to digital converter :

This option was initially raised in case we need more pins during the implementation of the project.

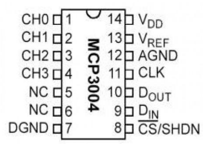
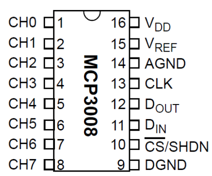
Analog to digital convertor				
Type	Image	Advantages	Disadvantages	Chosen / not
MCP3004		1 - low cost. 2 -small	It has only 4 channels .	✗
MCP3008		1 - low cost . 2 - small . 3 - it has 8 channels..	Disadvantages of this device Are not important for the system.	✗

Table 2.8: List ofAnalog to digital convertor options

Analysis: As shown in table 2.8, We didn't choose any one , because we didn't need extra analog to digital converters.

F) Battery :

To operate the system we need a power supply , so we studied our choices for that and we found that we need a suitable size power supply and a chargeable one.
Our choice was between 3 types as shown in **Table 2.9**.

Battery				
Type	Image	Advantages	Disadvantages	Chosen / not
Lithium ion		1 - lower cost 2 - lightweight.	less energy .	✗

Lithium polymer		1- large energy density. 2 - suitable size. 3 - safer . 4 - .lightweight.	Higher cost .	✗
Power bank		1 - large energy density. 2 - chargeable.	higher cost	✓

Table 2.9: List of Battery options

Analysis: As shown in table 2.9, We chose a power bank because it’s chargeable and has a larger energy density .

G) Bending sensors :

Detecting the bending of fingers is necessary to detect the sign. In order to measure this finger bending , we need a sensor on the finger, and the reading is variable according to the extent of the finger's bending.

Our choice was between two types of sensor as shown in **Table 2.10.**

.

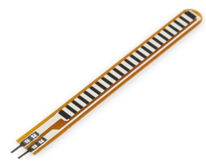
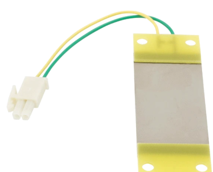
Bending Sensors				
Type	Image	Advantages	Disadvantages	Chosen / not
Flex sensor		1 - long enough. 2 - lightweight. 3 - It does not affect finger movement.	Higher cost.	✓
strain gauges sensor		1- lower cost. 2 - lightweight.	Does not fit finger length .	✗

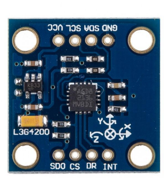
Table 2.10: List of Bending sensors

Analysis: As shown in table 2.10, We chose the flex sensor because it fits finger length and it does not affect finger movement .

H) Orientation sensor :

In sign language, for every gesture there is a specific orientation , to determine and know this orientation we need a sensor to measure this rotation on the three axes (x,y,z). This sensor is called Gyroscope.

Between the three choices we have , we preferred to use MPU6050 because it combines an accelerometer and gyroscope.

Orientation sensors				
Type	Image	Advantages	Disadvantages	Chosen / not
Gyroscope		1 - Works in all three dimensions. 2 - measures the absolute orientation. 3 - suitable size.	Higher cost.	✓

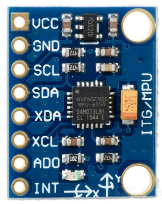
Compass		1- lower cost. 2 - suitable size.	Works only in 2 dimensions.	✗
Mpu 6050		consists of three-axis accelerometer and three-axis gyroscope	It has only 6 degree of freedom while other gyro and accelerometer sensors has 9 and 10 degree of freedom	✓

Table 2.11: List of orientation sensors

Analysis: As shown in table 2.11, We choose Mpu 6050 because it measures all three dimensions (x,y,z) orientation and accelerometer which will minimize the hardware complications.

2.5 System Constraints:

1- The mute person can hear others.

2- Gloves have to be worn by hands.

3- Power availability:The power bank should be charged all the time.

4- Glove is always on.

5- Calibration: the right hand should be fixed in a horizontally and vertically position.

6- To enable sentence mode you need to push a button located on the left hand.

Chapter Three
System Design

3.1 Overview:

In this chapter, we will explain the abstract block diagram of the system. Next, showing the detailed conceptual description of the system and the detailed design for each component including its schematic diagram. Finally, we will explain the schematic diagram for the hardware components of the system.

3.2 Detailed conceptual description of the system:

As shown in figure 3.1, The system consists of two parts: right hand and the left hand.

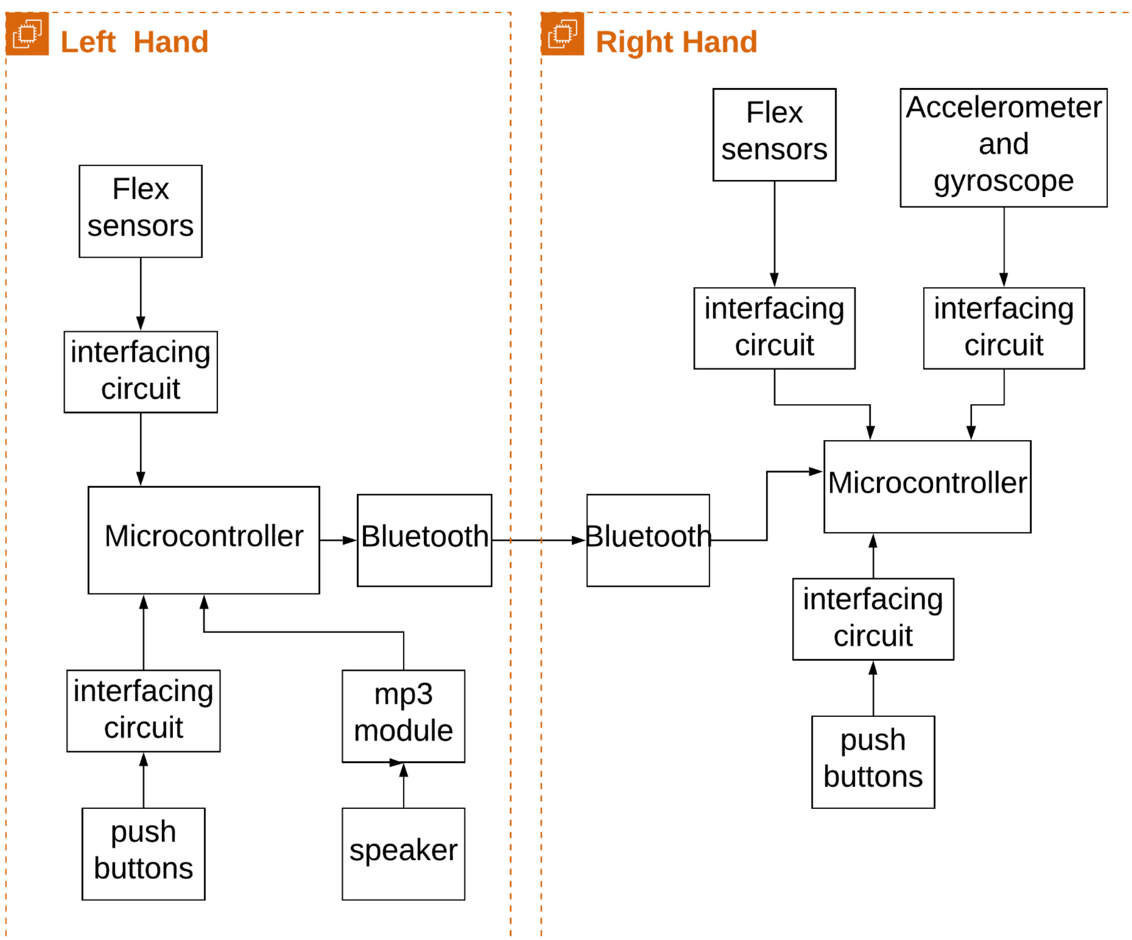


Figure 3.1: abstract block diagram of the system

Right hand: this part of the system consists of multiple sensor components to read the hand gestures, and a microcontroller to process the data received from sensor components, and a bluetooth module to be used for communication between the two hands.

Figure 3.2 shows The system components. It consists of 3 parts:

1- The sensors Component:

The flex sensors: nine flex sensors will capture the pending of the fingers joints as a main part of the gesture detection system.

The accelerometer: these two sensors will capture the orientation and the acceleration of the hands movements in the 3 - axis to make the gesture detection process more accurate, as there are a lot of signs that have similar fingers pending but it has a different orientation.

Push buttons: one push button is used to control the process of capturing the hand gesture when a sign is performed.

2- The processing component:

The Arduino NANO MicroController: a processing unit is needed to read the values of the sensors using Analog to digital data pins, store these values and process it to be classified to the corresponding word.

3- The communication module:

Bluetooth: an HC-05 bluetooth module is used to communicate with the left hand and send the word classified.

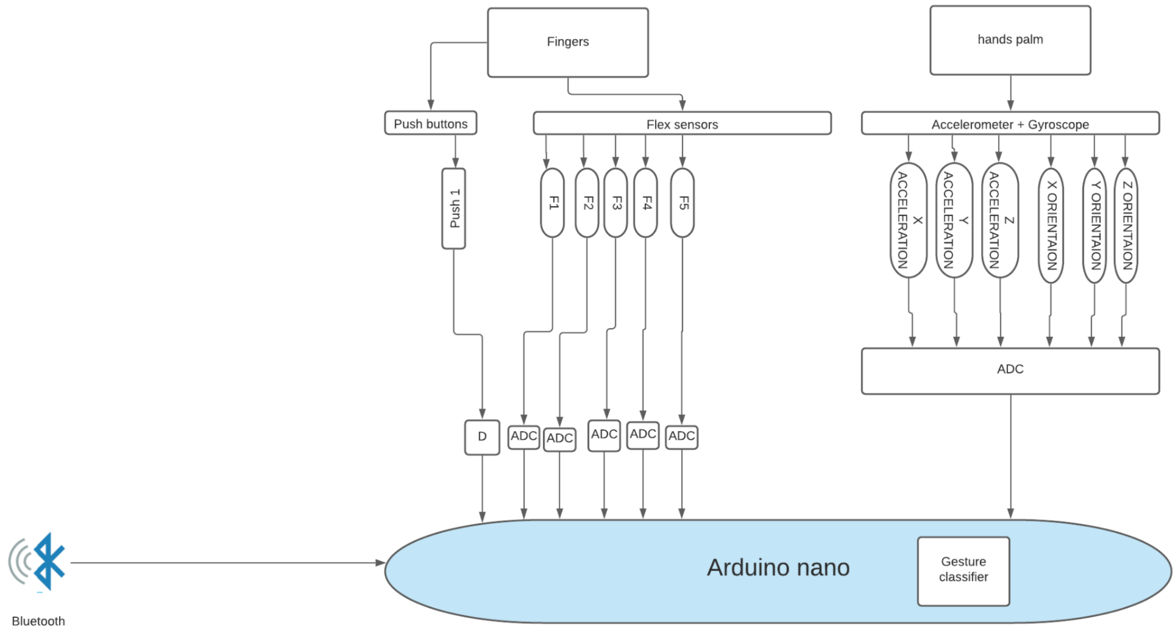


Figure 3.2: Distribution all the sensors and pushbuttons on the right hand glove

Left hand: this part of the system consists of multiple sensor components to read the hand gestures, and a microcontroller to process the data received from sensor components, and a communication module which is a bluetooth module to send the data to the other part of the system (the right hand)

Figure 3.3 shows the sensor components. It consists of 3 parts:

1- The sensors component :

The flex sensors: 5 flex sensors will capture the pending of the fingers joints as a main part of the gesture detection system.

Push buttons : 3 push buttons are used to control the process of capturing the hand gesture when a sign is performed, and detect if sentence mode is on or off, and if the sentence has a positive or negative manner.

2- The processing component:

The Arduino NANO MicroController: a processing unit is needed to read the values of the sensors using Analog to digital data pins, store these values and process it to be classified to the corresponding word.

3- The communication module:

Bluetooth: an HC-05 bluetooth module is used to communicate with the right hand to send the values of its sensors enhancing the gesture detection, and receiving the word to be displayed as audible sound.

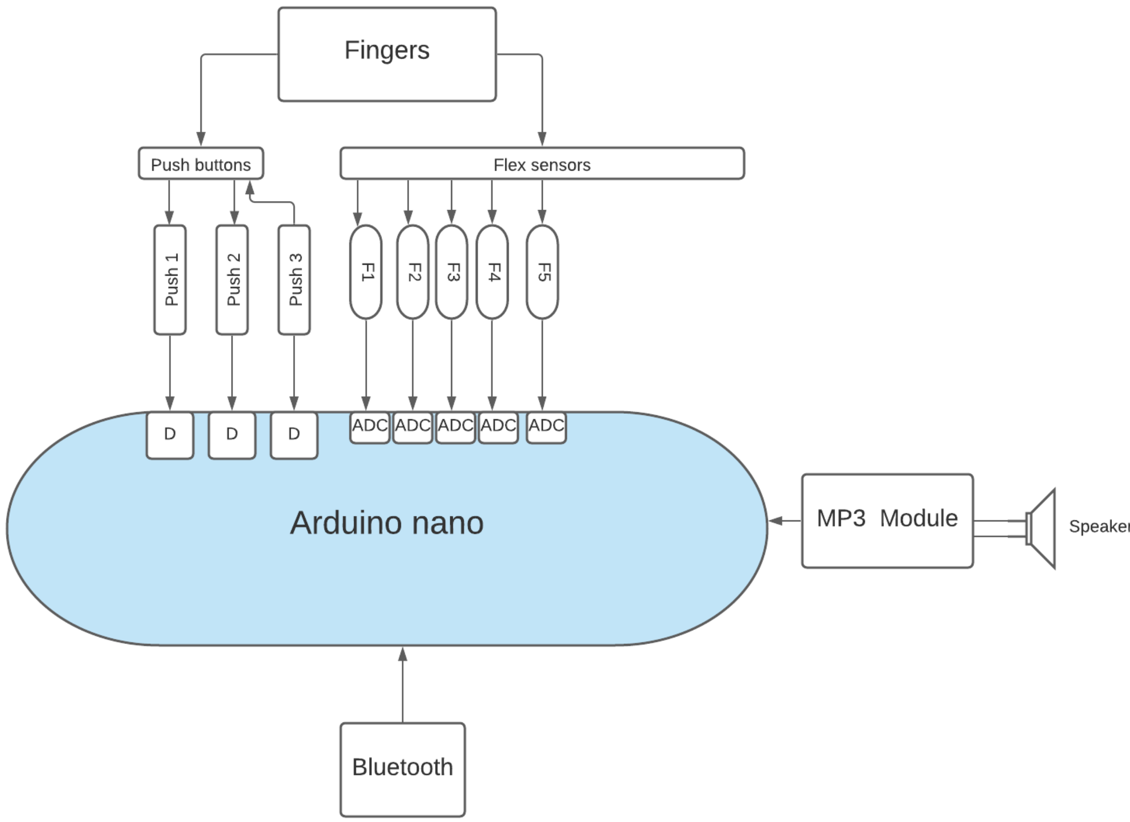
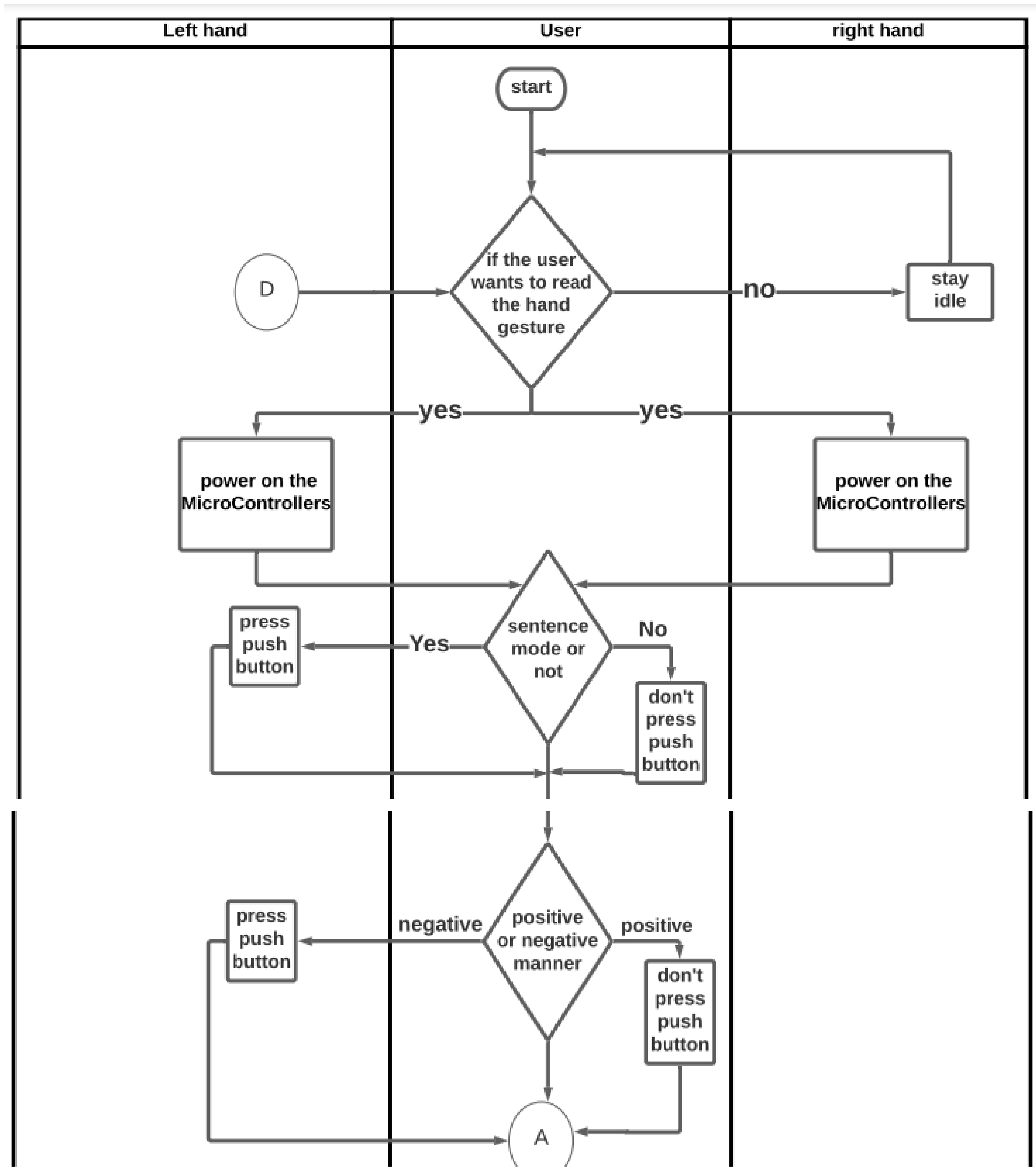
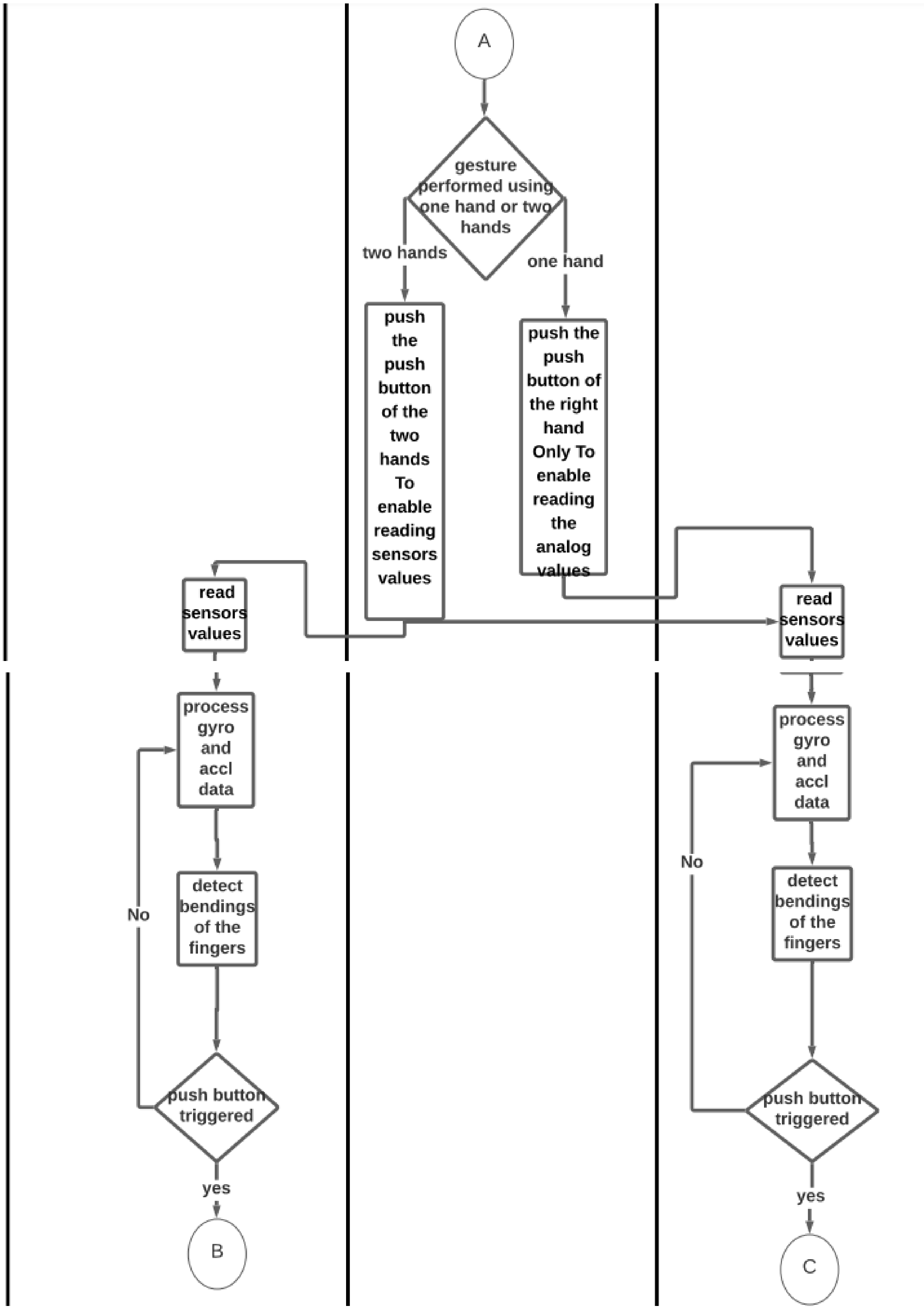


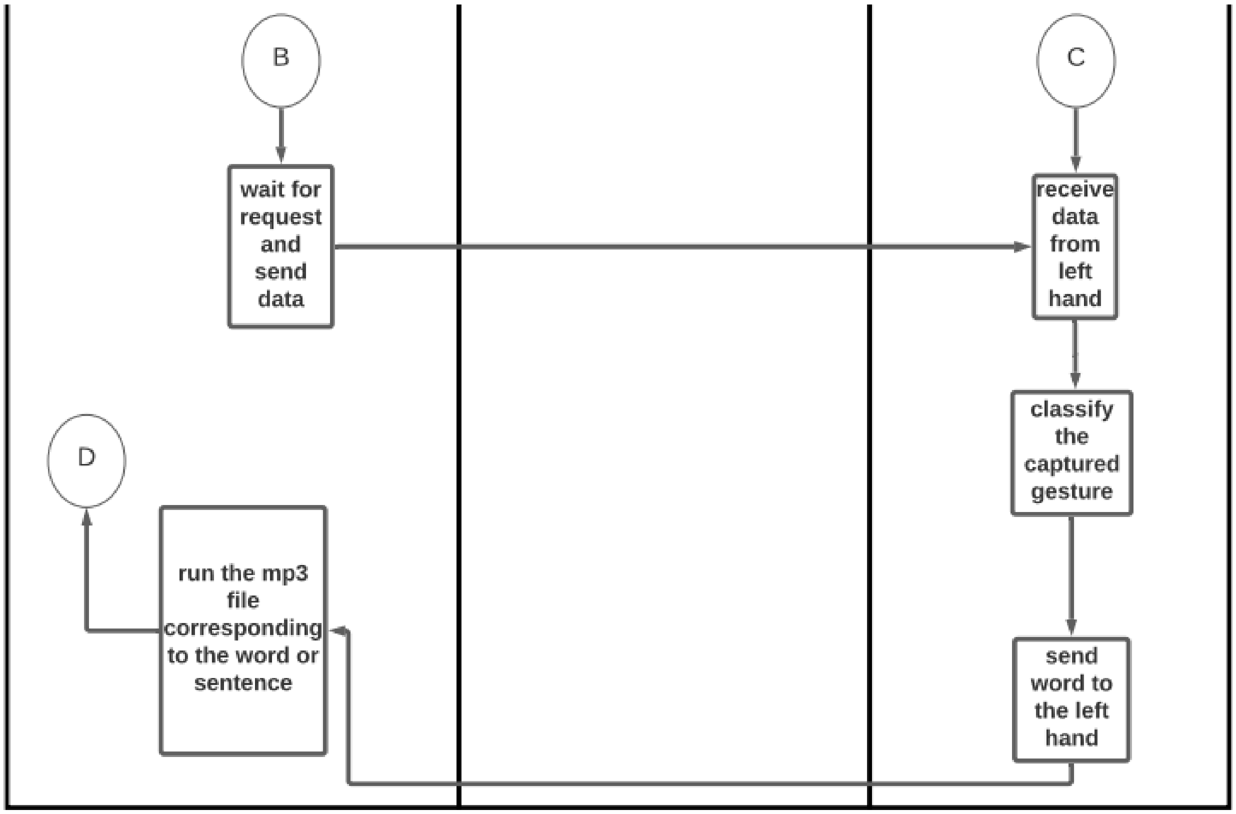
Figure 3.3: Distribution all the sensors and pushbuttons on the Left hand glove

3.3 System Event Diagram:

An event driven diagram is the interaction between the user , the right hand, and the left hand.




A
gesture performed using one hand or two hands
two hands
one hand
push the push button of the two hands To enable reading sensors values
push the push button of the right hand Only To enable reading the analog values
read sensors values
read sensors values
process gyro and accl data
process gyro and accl data
detect bendings of the fingers
detect bendings of the fingers
No
No
push button triggered
push button triggered
yes
yes
B
C


B
C
wait for request and send data
receive data from left hand
classify the captured gesture
D
run the mp3 file corresponding to the word or sentence
send word to the left hand

3.4 Hardware Design:

Right hand Push Button:

The interfacing circuit between start/end sign pushbutton with arduino nano is shown in the schematic diagram in figure 3.4:

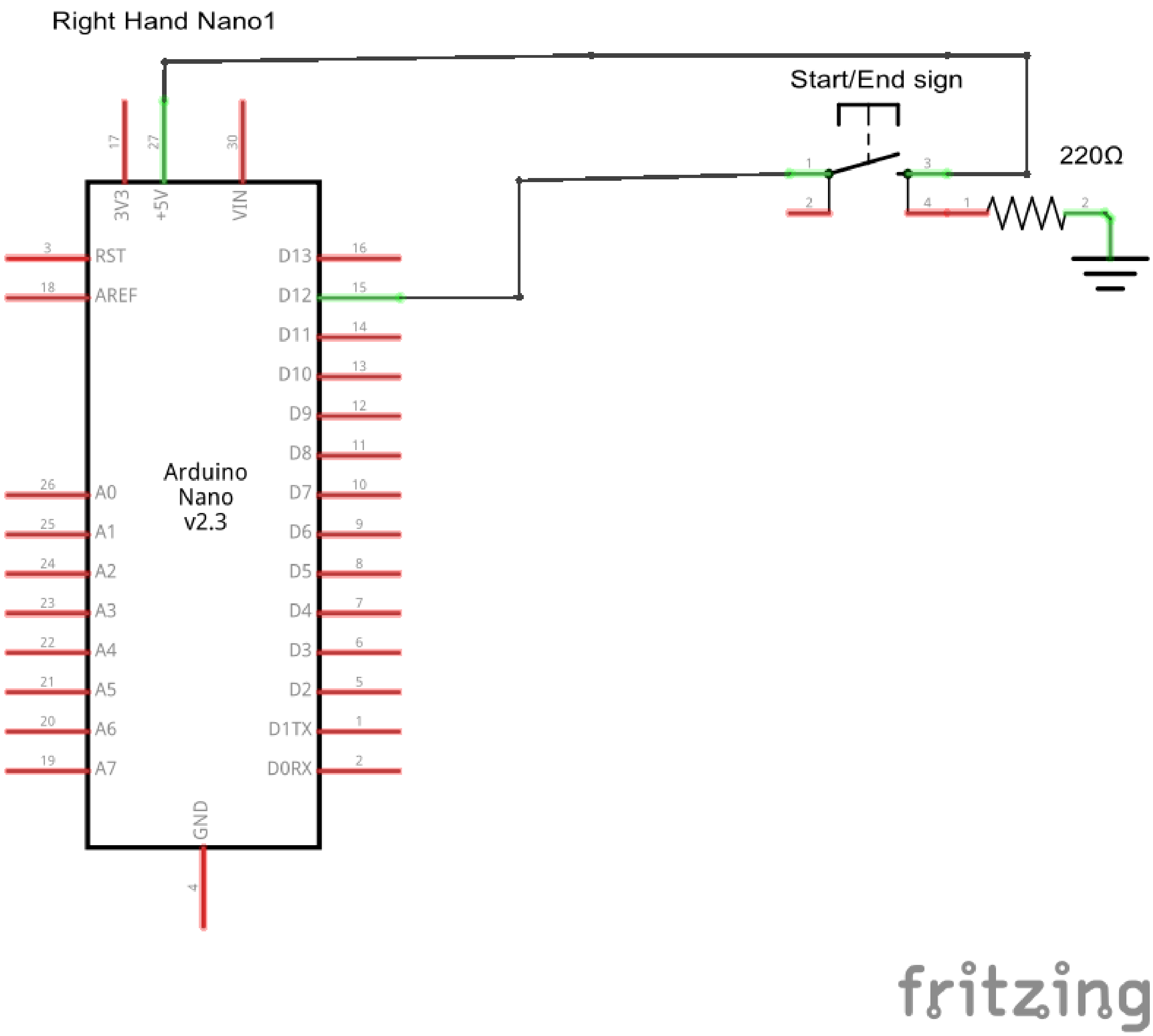


Figure 3.4:Schematic diagram for push buttons connected with arduino nano

Right hand Flex Sensors:

The interfacing circuit between the five flex sensors with arduino nano is shown in the schematic diagram in figure 3.5:

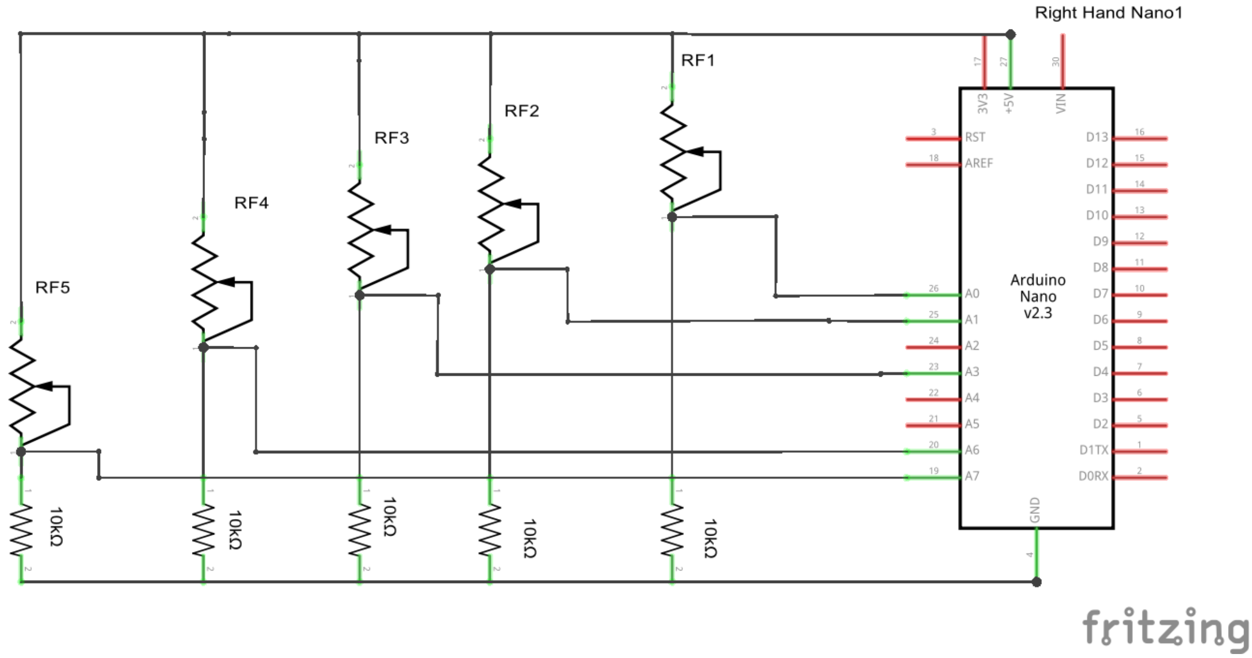


Figure 3.5: Schematic diagram for Flex connected with arduino nano

Right hand GyroScope, Accelerometer:

The interfacing circuit between MPU6050 with arduino nano is shown in the schematic diagram in figure 3.6:

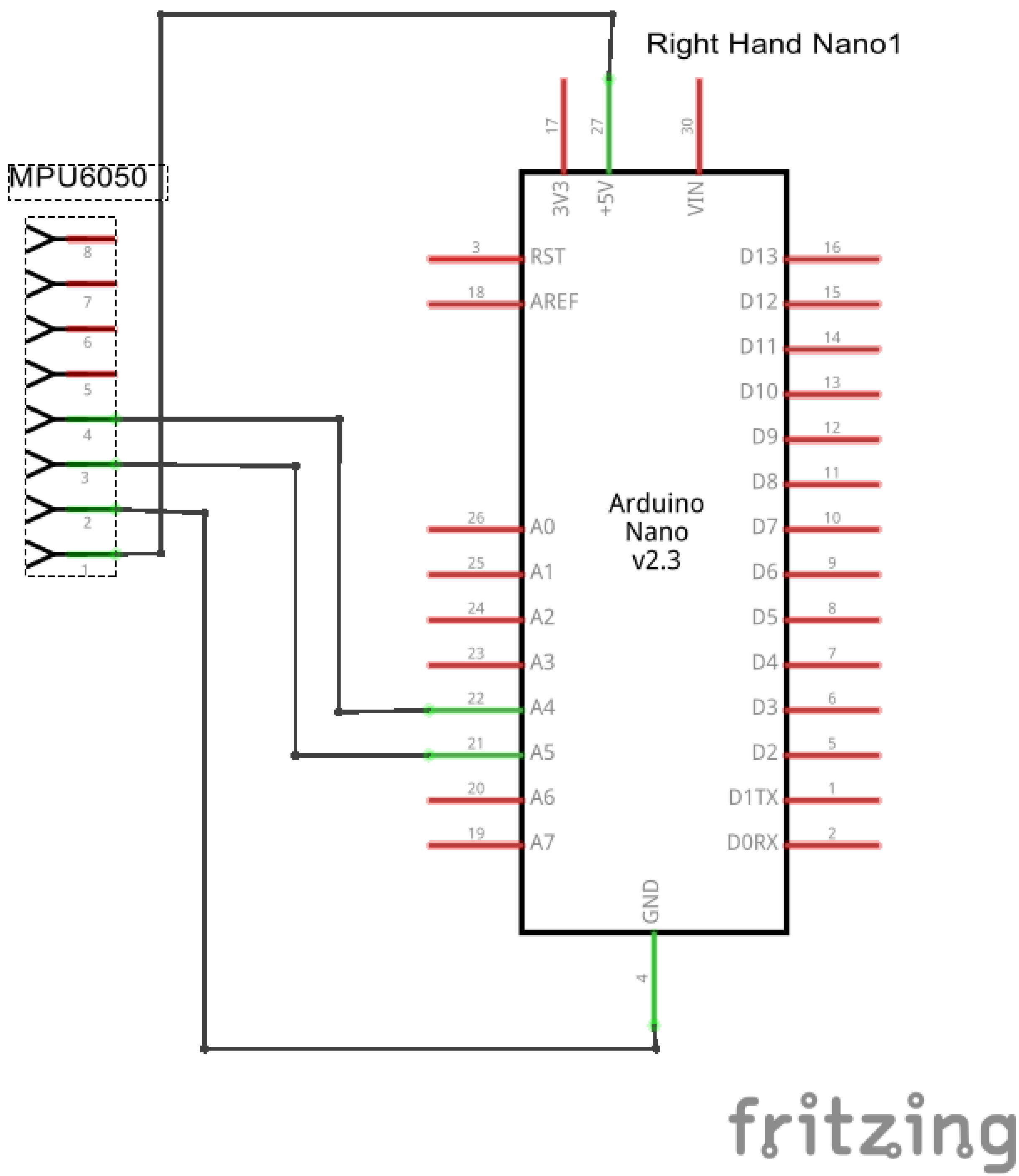


Figure 3.6: Schematic diagram for MPU6050 connected with arduino nano

Right hand Bluetooth module:

The interfacing circuit between HC05 with arduino nano is shown in the schematic diagram in figure 3.7:

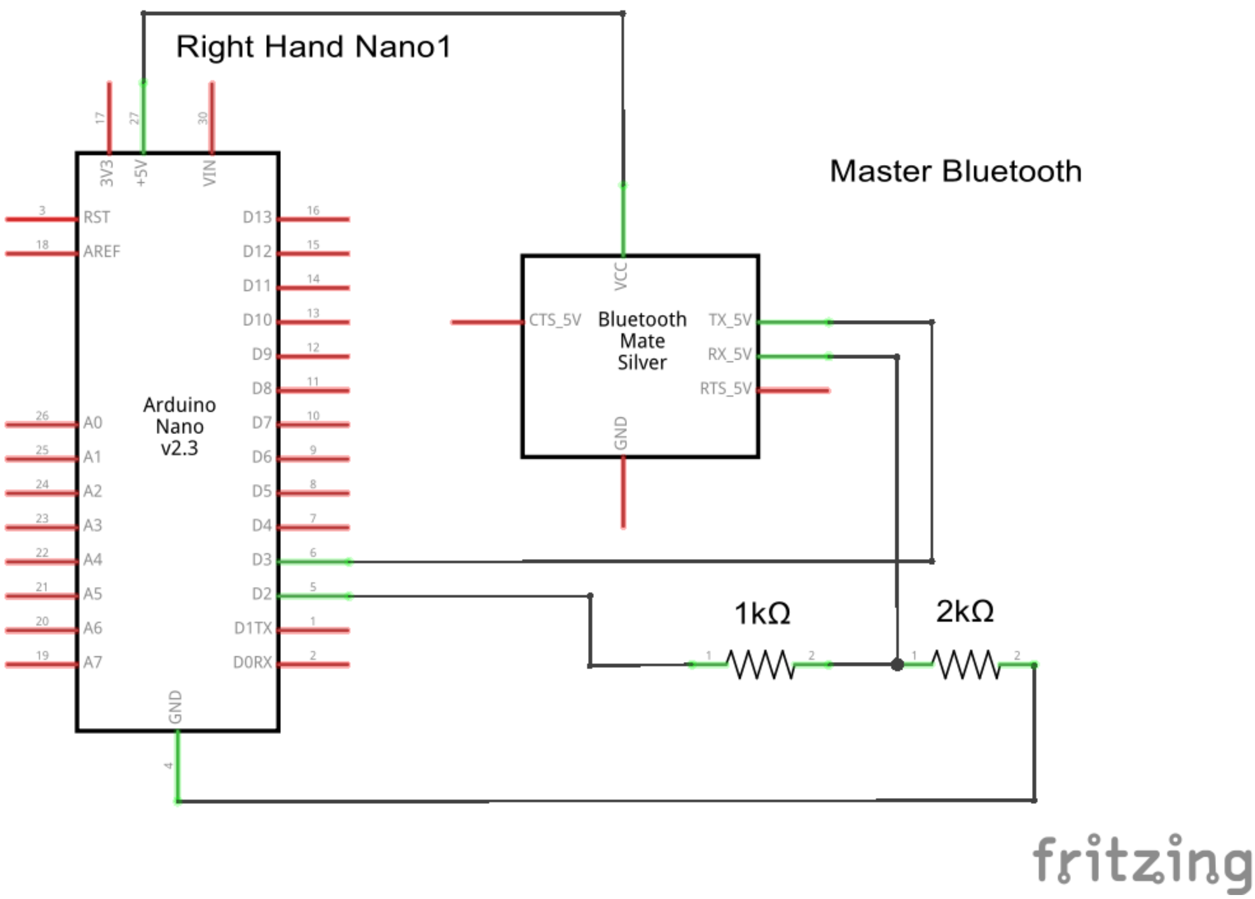


Figure 3.7: Schematic diagram for HC05 connected with arduino nano

Left Hand Flex sensor:

The interfacing circuit between the Flex sensors and the arduino nano is shown in the schematic diagram in figure 3.8:

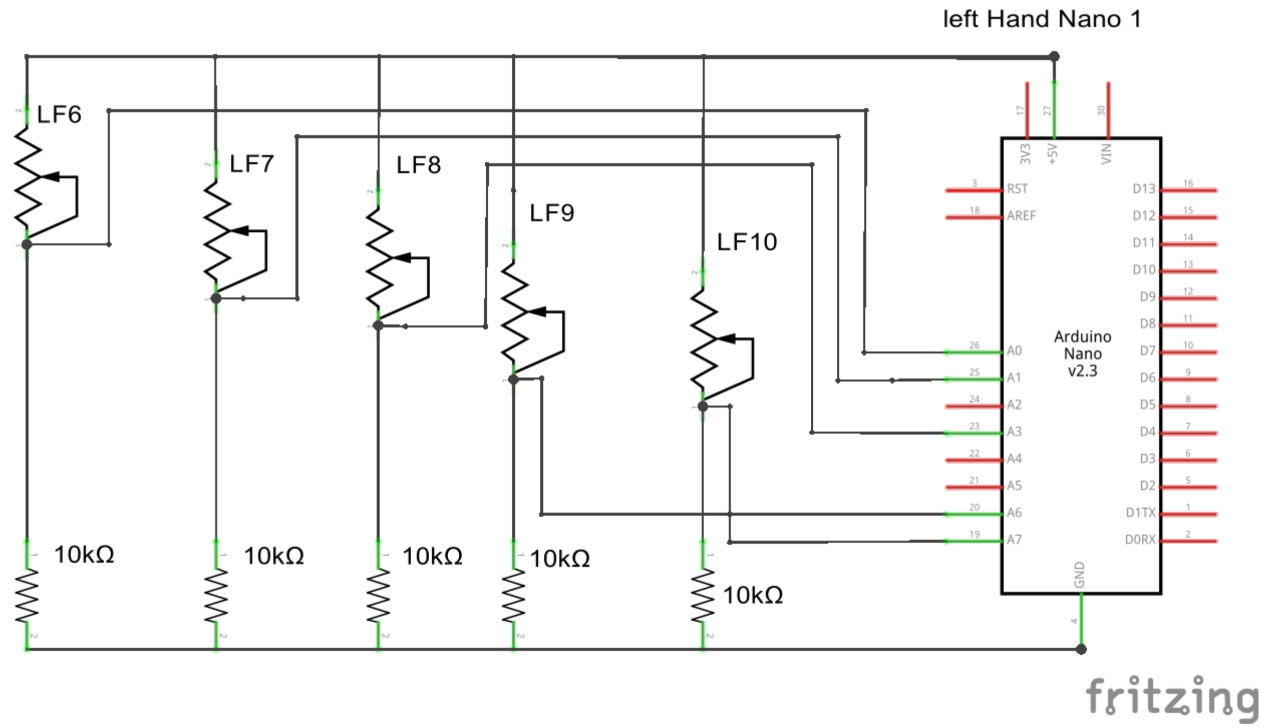


Figure 3.8: Schematic diagram for Flex connected with arduino nano

Left Hand Push buttons :

The interfacing circuit between the push buttons NANO is shown in the schematic diagram in figure 3.9:

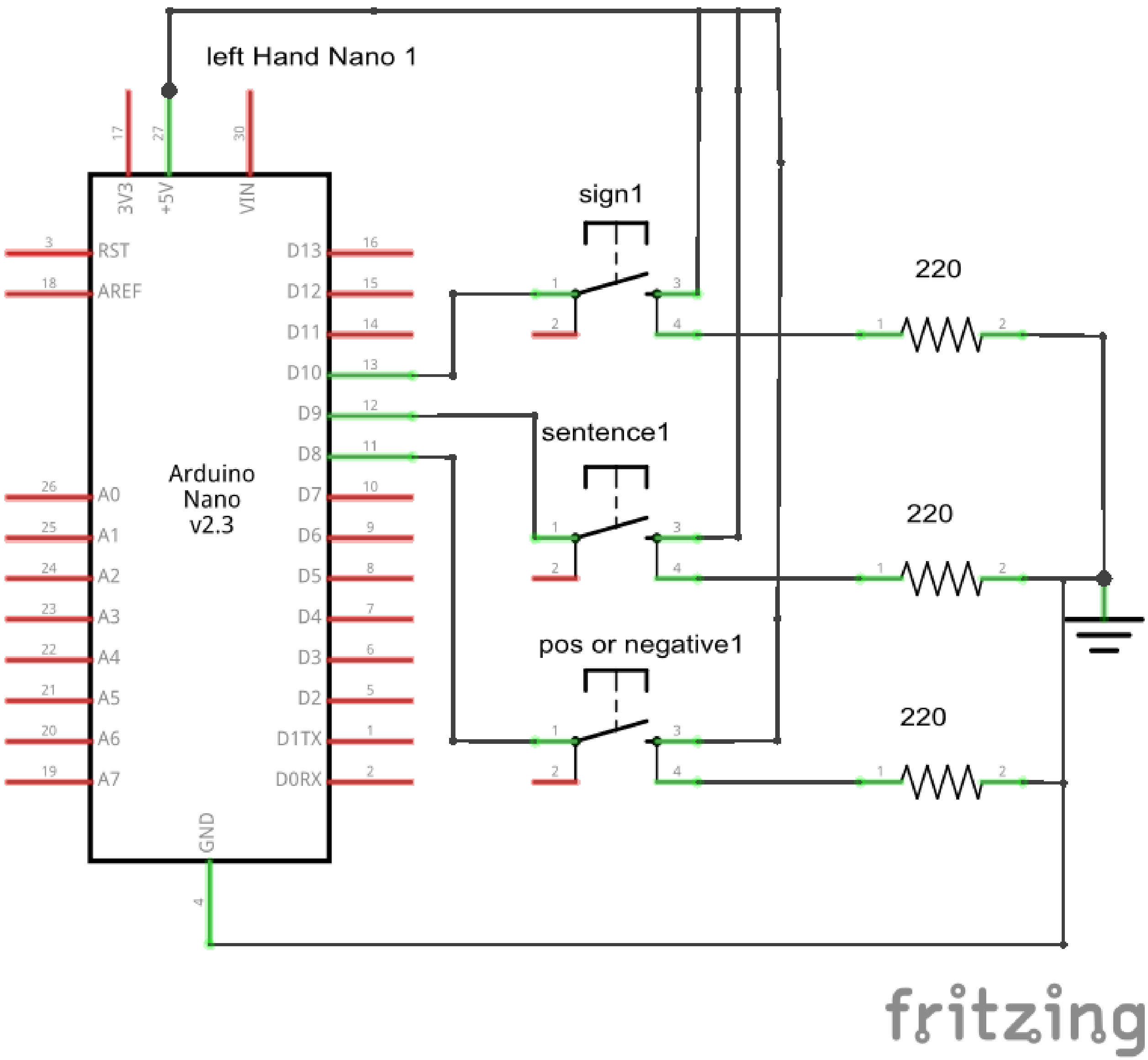


Figure 3.9: Schematic diagram for push buttons connected with arduino nano

Left hand Bluetooth module:

The interfacing circuit between the HC-05 Bluetooth and the arduino nano is shown in the schematic diagram in figure 3.10:

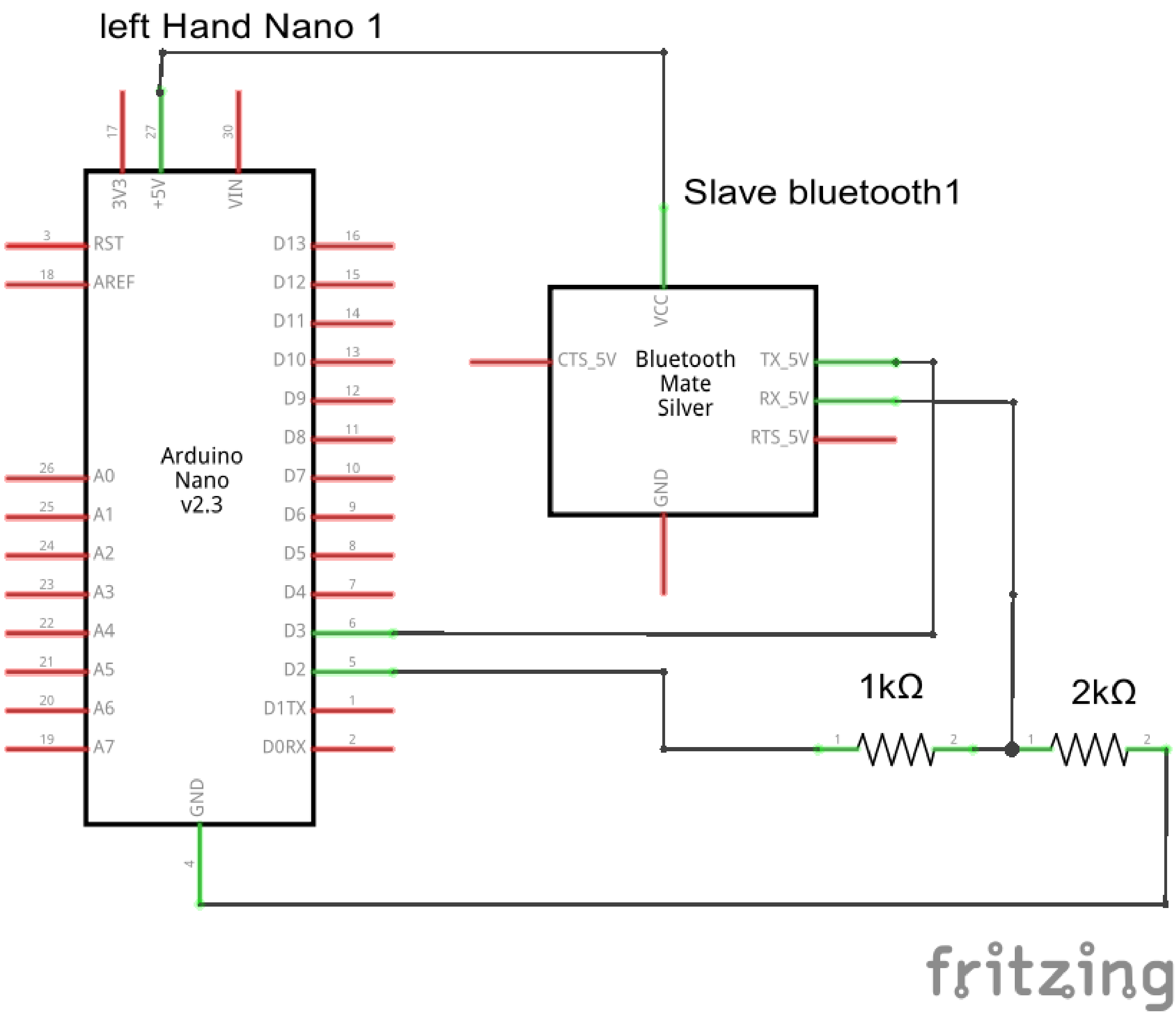


Figure 3.10: Schematic diagram for HC-05 Bluetooth connected with arduino nano

Left hand MP3 module and speaker:

The interfacing circuit between the DF3 mini module and the speaker with arduino nano is shown in the schematic diagram in figure 3.11:

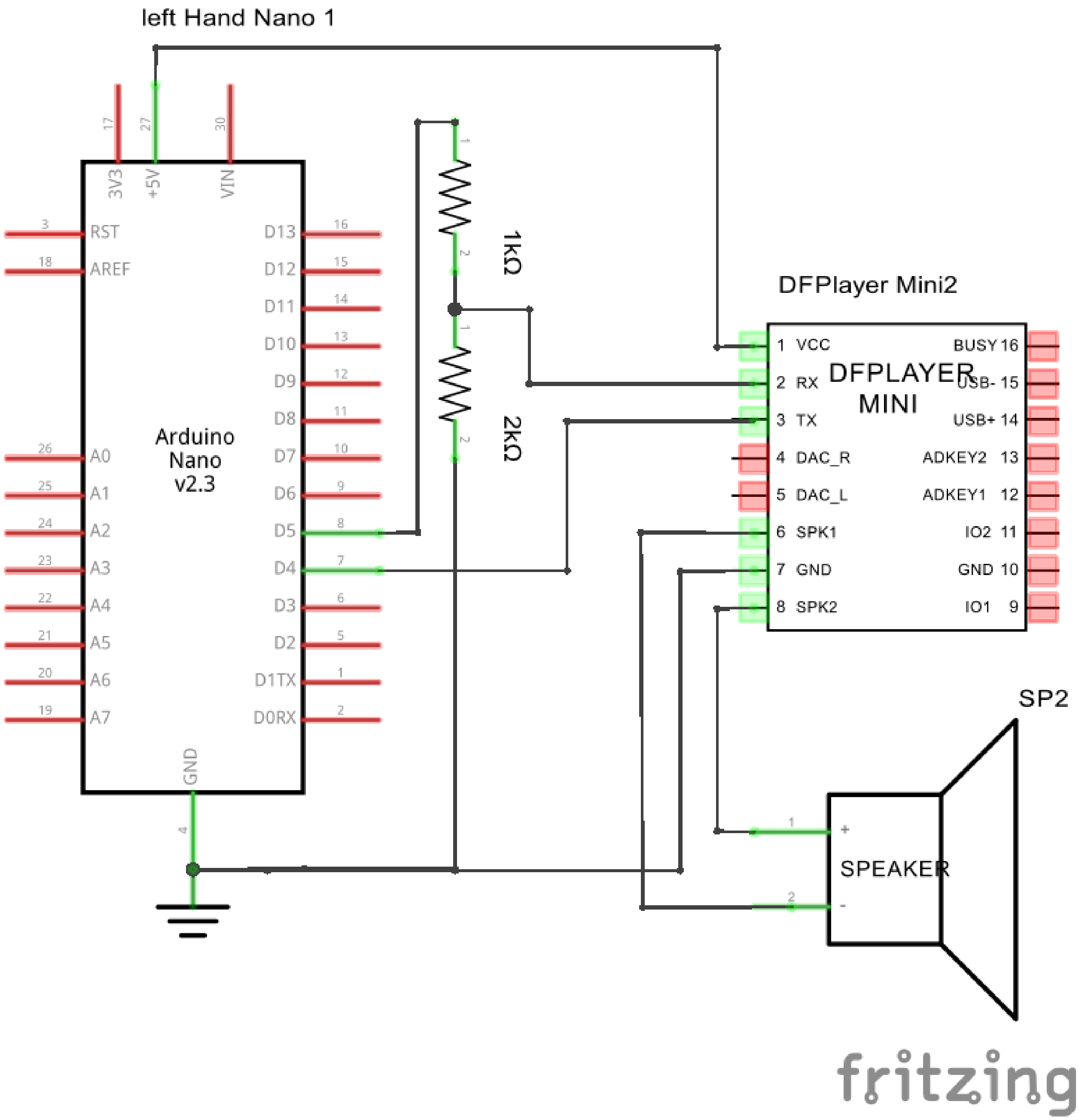


Figure 3.11: Schematic diagram for df3 mini player and speaker connected with arduino nano

Chapter Four

System Implementation

4.1 Overview:

This chapter describes the implementation of the software and the hardware of this project, such as the circuit connection, microcontroller, and the IDEs which are used to build the project codes.

4.2 Hardware Implementation:

Starting with Arduino Nano V3.0, we successively connected the other system components as follows:
In the right hand:

1. We connected Arduino Nano V3.0 with Bluetooth Module HC-05 (Master), to communicate with the left hand.
   Result:
   The communication between the two gloves was done successfully using 2 bluetooth modules in each glove.

2. We connected Arduino Nano V3.0 with five Flex Sensors located on the joints of fingers using analog pins in the microcontroller, so that we can measure the bend degree of each sensor.
   Result:
   The flex sensors gave readings that indicate whether the fingers are bended or not , and the degree of the bending.

3. We connected Arduino Nano V3.0 with one push button located on the index finger of the glove using a digital pin; this button used to start and end the sign.
   Result:
   The push button succeeds to start and end reading the hand gesture.

4. We connected Arduino Nano V3.0 with MPU6050 using analog pins to measure acceleration and orientation of the hand in the 3-axes (x , y , z).

Result:
The MPU6050 gives the changes in gravitational forces of the three axis x, y and z. Based on these changes; To distinguish between similar bending signs.

5. We used a lithium ion chargeable battery to power the Arduino nano, it has LED charging indicator, power capacity of 2600mA with minimum capacity of 2470mA, output rate of 5V/1A, cycle time more than 500, it needs charging time of 2-3 hours
   Result:
   The chargeable battery operates the microcontroller successfully , and has the option of turning the microcontroller OFF.

6. Finally, we installed the microcontroller circuit described above on the glove as follows:
   1. We installed five flex sensors, which represent the bend degree of the middle joint of the finger.
   2. We installed one pushbutton, which is pressed to start and end the sign.
   3. We installed the MPU6050 sensor on the glove.
   4. We installed the Bluetooth module on the glove.
   5. We installed Arduino Nano V3.0 on the wrist and connected all components (flex sensors, pushbutton, MPU6050, Bluetooth) with Nano pins.

In the left hand:

1. We connect Arduino Nano V3.0 with Bluetooth Module HC-05 (Slave) , to communicate with the left hand.
   Result:
   The communication between the two gloves was done successfully using 2 bluetooth modules in each glove.
2. We connect Arduino Nano V3.0 with five Flex Sensors located on the joints of fingers using analog pins in the microcontroller, so that we can measure the bend degree of each sensor.
   Result:
   The flex sensors gave readings that indicate whether the fingers are bended or not , and the degree of the bending.
3. We connect Arduino Nano V3.0 with Three push buttons. One of them is located on the index finger and the other two are located on the board.
   Result:
   The push buttons are responsible on :

1 - Start reading the hand gesture and ending.
2 - Turning to the sentence mode.
3 - choosing between positive and negative in the sentence mode.

4. We used a lithium ion chargeable battery to power the Arduino nano, it has LED charging indicator, power capacity of 2600mA with minimum capacity of 2470mA, output rate of 5V/1A, cycle time more than 500, it needs charging time of 2-3 hours
   Result:
   The chargeable battery operates the microcontroller successfully , and has the option of turning the microcontroller OFF.
5. Finally, we installed the microcontroller circuit described above on the glove as follows:
   1 - We installed five flex sensors, which represent the bend degree of the middle joint of the finger.
   2 - We installed three pushbuttons , which are pressed to start and end the sign , turning on sentence mode , and choosing between positive and negative sentences.
   3 - We installed the Bluetooth module on the glove.
   4 - We installed Arduino Nano V3.0 on the wrist and connected all components (flex sensors, pushbutton, MPU6050, Bluetooth) with Nano pins.

4.3 Software Implementation:

Arduino Code Implementation:

We used Arduino IDE to program the Arduino microcontroller and write the code. Overall code of the system composed of the following modules:

1- Flex Sensors reading code:
Since we used analog pins to read the voltage between the flex resistor and the voltage divider resistor using analog pins, we used the analog read function to read the voltage values.

2- MPU6050 reading code:

The mpu6050 has 6 degrees of freedom in which it gives 6 readings which are the gravitational acceleration angular rotation in the 3 axis. We needed to convert these values to meaningful values to help us differentiate the similar bending signs.
The code successfully processes these values to the required values for the system.

3- MP3 module code:

Since we have connected the speaker with the DF mini player module to operate with the stored mp3 files in the sd card , we needed to control it, so we used the “DFRobotDFPlayerMini”, in which we can give it the name or index of the mp3 file to play it.

4- Communication

To connect the right hand Arduino Nano V3.0 with The left hand Arduino Nano V3.0 a Bluetooth connection is needed. We make a connection between Bluetooth Module CH-05 and another Bluetooth Module CH-05.

Bluetooth code:

Implement a Bluetooth connection between the two hands using the “easy transfer” library:

A. Slave bluetooth code:

This code will receive the data of the sensors from the left hand, which are the bending of the left hand fingers, then after classifying the hand gesture by the right hand it will send the name of the sign done by the user to the master bluetooth.

B. Master bluetooth code:

This code will send the data of the sensors from the left hand, which are the bending of the left hand fingers, then after classifying the hand gesture by the right hand it will receive the name of the sign done by the user from the slave bluetooth.

4.4 Implementation Issues:

During the course of the project implementation, we faced many obstacles and had to take several issues to reach the most suitable design of the system and reach the best properties related to the project’s aims. The following is a summary of these issues:

1. The installation of the flex sensors : flex sensor is a sensitive sensor so that its reading changes with any simple movement. We installed the flex sensors through sewing, which led to the stability of the sensor and its readings well.

2. Implementing ESP32 : we faced a problem with ESP32 which is the communication between it and the HC-05 module. It was better to use another HC-05 in the right hand , that’s why we have replaced the ESP32 with a cheaper and smaller microcontroller.

3. Glove material : we tried several gloves and we met issues according to the glove material. This is because we have a lot of flex sensors which become very annoying if the glove material is thin.

4. We faced many issues related to size and efficiency, so we tried several experiments to find the most suitable and achievable choice for the microcontroller and other components according to the requirements of the project.

The solutions to the previous implementation issues that we encountered:

1. The appropriate microcontroller for the system is Arduino Nano V3 supported with enough analog and digital pins. It also has a suitable size. The Analog-pins in Arduino Nano connect with flex sensors and accelerometer to control the bending degree of each flex sensor and digital pins connect with pushbuttons.

2. To solve the problem of Words with similar bending values, we used the mpu6050 to distinguish between words based on the hand movement.

3. To make a connection between the right Arduino and the left one we used two Bluetooth HC-05.

4. To avoid glove material problems we chose a thick glove to install the pieces on it.

4.5 Implementation Results:

By the end of the implementation process, the ArSLSG (shown in figure 4.2) was constructed successfully.
(Figure 4.1 a) shows the left hand glove, on which all components are fixed.
(Figure 4.1 b) shows the right hand glove, on which all components are fixed.
Detailed information about the connectivity of these components are presented in Section 3.2.

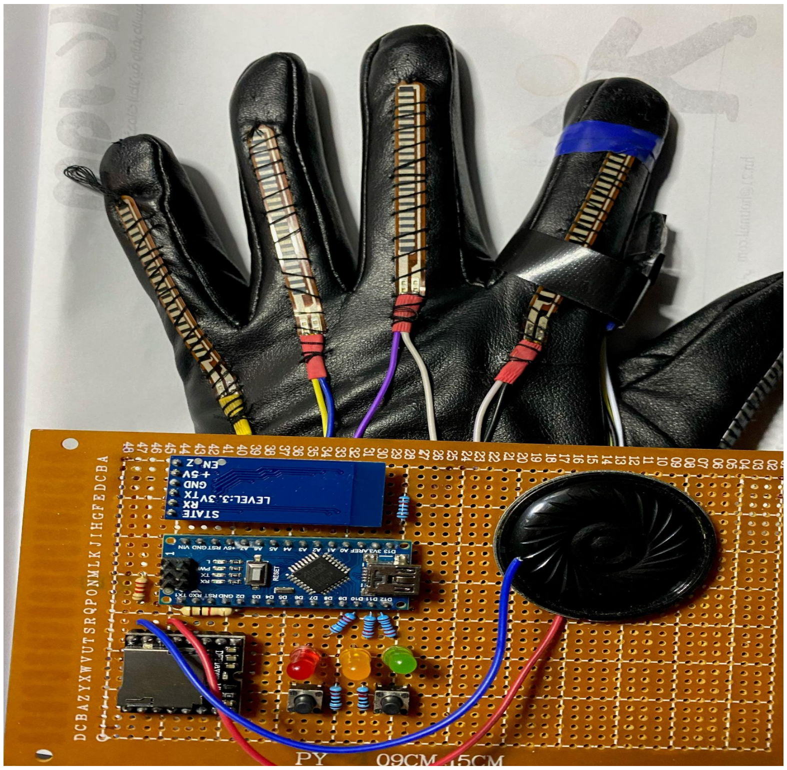


Figure 4.1a: Left hand glove.

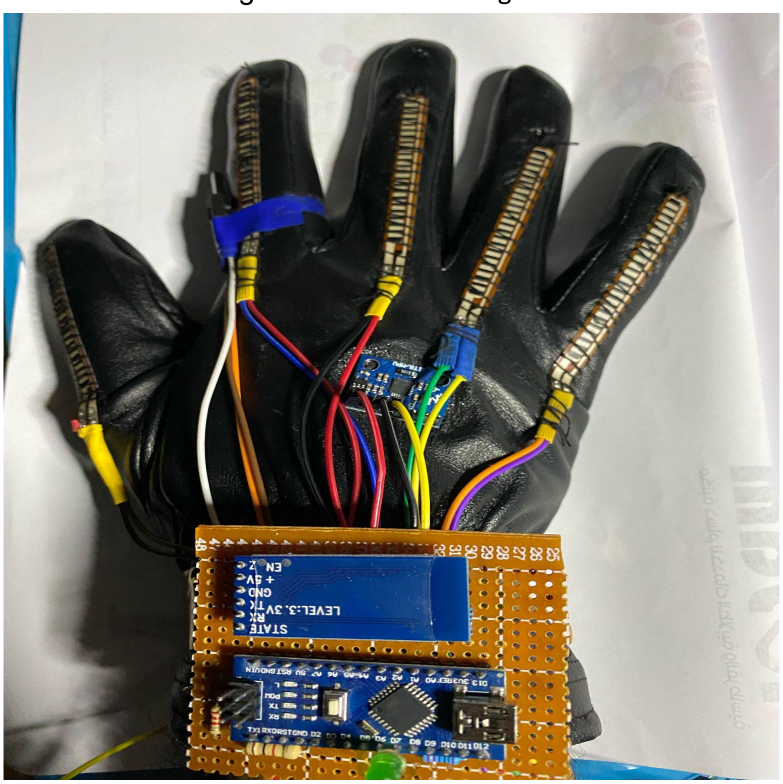


Figure 4.1b: right hand glove.

Chapter Five

Validation and Testing

5.1 Overview:

This chapter describes testing and validation of all components of the system and the results obtained. Test all parts to make sure all features are working properly and error-free.

5.2 Hardware Testing:

In this section we will discuss the testing of all hardware components :

1. Testing flex sensors

The first test of the flex sensors we connected the sensors directly with Vcc and ground through a 40K resistor to Arduino Nano to examine the sensor and the degree of bend and it worked successfully.

2. Testing pushbuttons

To test the push buttons we connected them with Arduino and tried to turn on and turn off a leds to check the buttons and tried to print buttons reading on the serial monitor in Arduino IDE and it worked successfully without any issues .

3. Testing Accelerometer and gyroscope sensor

To test the MPU6050 we connected it with Arduino nano analog pins, and we tried to put it in the best position to get the hand gesture properly, and see the result on the Arduino serial monitor. The measurements were accurate and we made sure of this by repeating the gesture more than once.

4. Testing Bluetooth Module HC-05

Connected 2 Bluetooth Modules HC-05 in each glove , the communication between them was done successfully. We checked that by sending the data from the left glove to the right hand glove’s microcontroller and it worked successfully.

5. Testing Arduino Nano N3.0

For testing the Arduino Nano we connected a led with it to check if the pins are working well or not.

6. Testing glove

There are many types of gloves, the choice of the type was based on how comfortable the glove is and not impeding the movement of the fingers.

7. Testing MP3 module with the speaker :

For testing the MP3 module we connected it with a speaker. Our choice of the speaker type was based on many trials on different types of speakers ,and we chose a speaker based on the range, quality of the sound and its size to be suitable on the glove.

5.3 System Testing

Test Arabic sign language speaking glove:

At the end, we tested the overall system “final construction of the two gloves as ArSLSG”. This includes checking all the following points:

a. Check Arduino Nano with flex sensors.
b. Check Arduino Nano and MPU6050.
c. Check Bluetooth connection between two HC-05 modules.
d. Check Bluetooth modules validity to send and receive different types of data.
e. Check the validation of the pushbuttons in each glove.
f. Check the classification of the signs.
g. Check the arduino nano with the mp3 module and the speaker.

5.4 Error rate for the system

After we tried all the words implemented in the system, Table 5.1 shows the error rate for each word within 15 trials.

Word	Error rate
انا	0/15
أنت	0/15
لي	0/15
لكم	1/15
لا	3/15
تكسي	1/15
باص	0/15
سيارة	0/15
نقود	0/15
طبيب	0/15
مريض	0/15
دواء	0/15
كتاب	0/15
قلم	0/15
بيت	0/15
مسجد	0/15
مدرسة	2/15
جامعة	0/15
سوق	0/15
مطبخ	0/15
حمام	0/15
طعام	1/15

ماء	0/15
انترنت	0/15
حاسوب	0/15
ملابس	0/15
السلام عليكم	0/15
شكرا	0/15
مشكلة	0/15
أحضر	1/15
أعمل	1/15
أذهب \ أمشي	1/15
أريد	0/15
أخت	0/15
أم	0/15
أب	0/15
أخ	0/15

Table 5.1: The error rate for each word.

Error rate for all the system $= \dfrac{\sum_{i=0}^{n-1} error\ rate\ for\ each\ word}{n}$

$= \dfrac{(6*(0.066) + 0.2 + 0.13333)}{37}$

$= \dfrac{0.73333334}{37}$

= 0.0198198198

Hence, the success rate of the system is 98.02%

Chapter Six

Conclusion

6.1 Conclusion

In this project , we constructed two gloves to translate the Arabic sign language into an audible speech to help the mute people to communicate with others who don't understand the Arabic sign language.
Two gloves have been used because most of the sign language words require both hands, the gloves are able to communicate through bluetooth. We also added a speaker rather than a display screen to be easier to communicate with others.
To make it easier for the mute people to communicate we add a sentence mode which will be able to convert the word to sentence. In each sentence, there are two choices,where the user will choose between them, which are : the positive mode in which the sentence is in a positive manner or a negative mode in which the sentence is in a negative manner.
The words and sentences in the project will cover the daily needs of the mute person and will make him/her able to express his/her needs and feelings.

6.2 Future Work

After accomplishing this project successfully , we look forward to add many features in the future, such as

- Mobile application to enable the user to add new signs, edit and delete existing signs.
- Artificial intelligence which will add efficiency , flexibility and accuracy.
- Cloud based processing for the classification of the sign using AI and machine learning using updated data sets.
- Two way communication system to help deaf and mute people, not just for mute people.

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