PROJECT REPORT

ON

"SMART GLOVE TO CONVERT GESTURES TO SPEECH AND HOME AUTOMATION"

Submitted in partial fulfillment of requirement for the degree of Bachelor of Technology in

Electronics and Telecommunication Engineering

Submitted By

NAYAN LENDE **YASH AMBILDHUKE**

SIDDESH YERAWAR **VED BOTKEWAR**

Under the guidance of

Mr. O.G. HASTAK

Department of Electronics and Telecommunication Engineering

Priyadarshini College of Engineering,

Nagpur – 440019

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CERTIFICATE

This is to certify that the project entitled "**SMART GLOVE TO CONVERT GESTURES TO SPEECH AND HOME AUTOMATION**" has been carried out by

NAYAN LENDE **YASH AMBILDHUKE**

SIDDESH YERAWAR **VED BOTKEWAR**

under my guidance and submitted the partial fulfillment for the degree of Bachelor of Technology (B.TECH.) in Electronics and Telecommunication Engineering, during the academic year 2024-25 is a bonafide work prepared by them.

This work fulfills the requirements relating the standard of work for the award of Bachelor of Technology in Electronics and Telecommunication to be awarded by Rashtrasant Tukadoji Maharaj Nagpur University, Nagpur.

Place: Nagpur

Date:

Mr. O.G. HASTAK
Guide

Dr. V.K. TAKSANDE **Dr. S.A. DHALE**
Head of Department Principal

ABSTRACT

Communication is a fundamental aspect of human interaction, yet individuals with speech impairments, paralysis, or disabilities affecting their motor skills often face significant challenges in expressing themselves. This project aims to the development of a "**SMART GLOVE TO CONVERT GESTURES INTO SPEECH AND HOME AUTOMATION**", enabling effective communication for paralyzed and speech-impaired individuals.

The smart glove is embedded with an ADXL345 accelerometer to detect hand movements and an array of flex sensors to capture finger bending patterns. The collected data is processed using an Arduino Uno microcontroller, which interprets the gestures and transmits signals via an NRF24L01 wireless module or Bluetooth module HC-05 to a mobile application. The application then converts these gestures into corresponding speech output, allowing users to communicate effortlessly. This assistive device aims to bridge the communication gap for individuals with disabilities by offering an affordable, portable, and user-friendly solution. The integration of real-time gesture recognition and voice synthesis enhances accessibility, making the system adaptable for various disabilities. Future enhancements may include machine learning algorithms for improved gesture recognition and multi-language support to increase usability across diverse linguistic groups.

Unlike previous assistive technologies, which cost over ₹2 lakh, the proposed model is developed with a focus on affordability and ease of use, ensuring that it is practical for widespread adoption, even in rural and underprivileged areas. By bridging the communication gap, this gesture-to-speech conversion system empowers individuals with disabilities to interact confidently, promoting social inclusion and improved quality of life.

The project aims to development of a glove for the paralysed and people with disabilities which can convert their hand gestures and movements into speech in any suitable language.

Keywords: Smart Glove, Gesture-to-Speech, Assistive Technology, Speech Impairment, Arduino, Cost-Effective Communication, Wireless Communication.

ACKNOWLEDGEMENT

Priyadarshini College of Engineering is a well-established & renowned institute and follows a goal of creating technocrats and brings it into reality, which will perform challenging endeavor in technical field for welfare of human being.

We wish to avail this opportunity to express our sincere thanks to our Guide **Mr. O.G. HASTAK**, who continuously supervised our work with utmost care and zeal. He has always guided us in our endeavor to present our project on "**SMART GLOVE TO CONVERT GESTURES TO SPEECH AND HOME AUTOMATION**".

It's a great pleasure to express our deep sense of gratitude and the wholehearted thanks to our principal **Dr.S.A. Dhale**, Priyadarshini College of Engineering, Nagpur.

We offer special thanks to our Head of the Department **Dr.V.K. Taksande**, for giving us the opportunity to undertake this project. We offer hearty gratitude to, Lab assistants of ETC Department, PCE, for their valuable support during the execution of the project work.

Lastly, we express our deep sense of gratitude to all teaching and non-teaching staff of the Institute and all our friends, family members, who directly and indirectly helped us to complete our project successfully and to bring it into reality.

NAYAN LENDE **YASH AMBILDHUKE**

SIDDESH YERAWAR **VED BOTKEWAR**

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CHAPTER-I

INTRODUCTION

I. INTRODUCTION

In an information-oriented society, all members of the Society have the right to obtain and use the information. Therefore, it is necessary to develop various devices, which can provide information to anyone easily. More than 15.4 million people worldwide were living with a spinal cord injury (SCI) and with other Physically challenged people like visually impaired or deaf-blind people are facing lots of problems while communicating or interacting with other people. To provide a helping hand towards the paralysed society, recent technological growth has been developing different skilled methods to enhance their communication procedures. Illiteracy among this group is very high, much of which is attributed due to the lack of reading material in accessible format. For reading and writing dumb and deaf people always use Sign language representation of different alphabets, symbols (as shown in Fig. 1) and digits (as shown in Fig. 2) etc. Sign language is the language used by the Dumb and deaf to read and write. It is vital for communication and educational purposes.

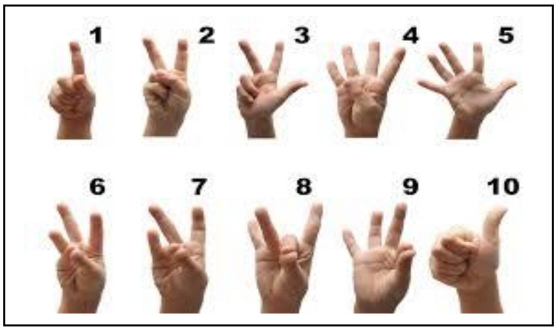


Fig 1: Numbers

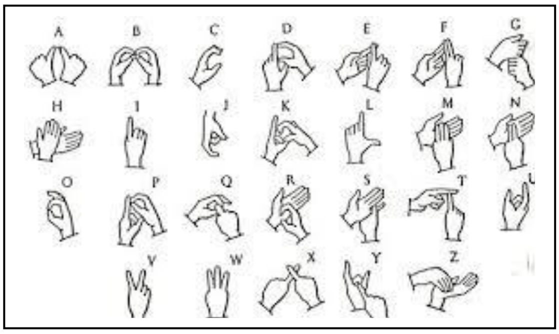


Fig 2: Alphabets

1.1 Background

Sign languages (also known as signed languages) are languages that use the visual-manual modality to convey meaning. Sign languages are expressed through manual articulations in combination with non-manual elements. Sign languages are full-fledged natural languages with their own grammar and lexicon. Sign languages are not universal and they are not mutually intelligible with each other, although there are also striking similarities among sign languages.

Linguists consider both spoken and signed communication to be types of natural language, meaning that both emerged through an abstract, protracted aging process and evolved over time without meticulous planning .Sign language should not be confused with body language, a type of nonverbal communication.

Wherever communities of deaf people exist, sign languages have developed as useful means of communication, and they form the core of local Deaf cultures. Although signing is used primarily by the deaf and hard of hearing, it is also used by hearing individuals, such as those unable to physically speak, those who have trouble with spoken language due to a disability or condition (augmentative and alternative communication), or those with deaf family members, such as children of deaf adults.

The number of sign languages worldwide is not precisely known. Each country generally has its own native sign language, and some have more than one. The 2021 edition of Ethnologue lists 150 sign languages, while the SIGN-HUB Atlas of Sign Language Structures lists over 200 and notes that there are more which have not been documented or discovered yet. As of 2021, Indo Sign Language is the most used sign language in the world, and Ethnologue ranks it as the 151th most "spoken" language in the world.

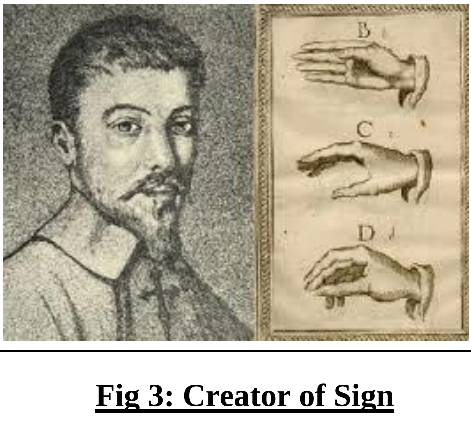


Fig 3: Creator of Sign

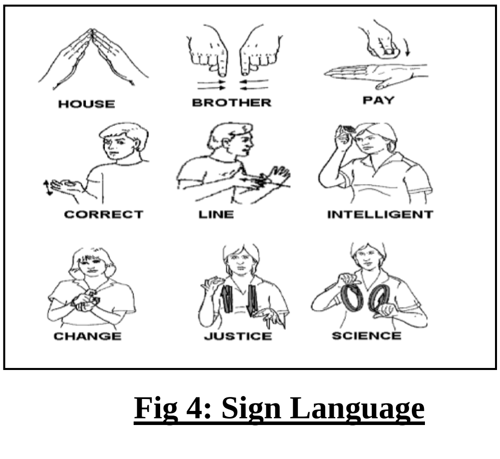


Fig 4: Sign Language

1.2 Necessity

Communication is a fundamental human right, yet millions of speech-impaired and paralyzed individuals struggle to express themselves due to physical limitations. Traditional sign language, though effective, is not universally understood, creating a significant communication gap between dumb, deaf, and paralyzed individuals and the rest of society. This leads to social isolation, dependency, and reduced opportunities in education, employment, and daily interactions.

Existing assistive devices, such as gesture recognition systems and speech-generating devices, are often expensive and inaccessible in developing countries like India, where affordability plays a crucial role in adoption. High-cost solutions (e.g., projects exceeding ₹2 lakh) are not feasible for mass deployment, leaving a large portion of the affected population without adequate support. Additionally, many rural areas lack access to computers and advanced technologies, making high-tech solutions impractical.

To bridge this gap, a cost-effective, portable, and user-friendly communication aid is essential. The Smart Glove aims to convert hand gestures into speech, providing a real-time, affordable, and practical solution for individuals with speech impairments and paralysis. By leveraging low-cost sensors, Arduino-based technology, and wireless communication, this project ensures that assistive technology is accessible to a larger population and can be deployed in homes, schools, and healthcare facilities.

This innovation empowers disabled individuals, enabling them to communicate independently, participate in society, and improve their quality of life. The necessity of this project lies in its ability to provide an affordable, efficient, and scalable solution to one of the most pressing challenges faced by the differently-abled community.

1.2 Objectives

The primary objective of this project is to develop a cost-effective and user-friendly Smart Glove that converts hand gestures into speech, enabling effective communication for speech-impaired and paralyzed individuals. This system aims to bridge the communication gap by providing an affordable, portable, and real-time assistive device that enhances the quality of life for people with disabilities.

The specific objectives of the project include:

1. To design and develop a wearable Smart Glove equipped with Combinational Circuit and an accelerometer to detect hand and finger movements accurately.
2. To implement a real-time gesture recognition system using an Arduino microcontroller that translates sign language gestures into meaningful speech.
3. To establish wireless communication using Bluetooth (HC-05) or NRF24L01 module for seamless data transmission to a mobile application.
4. To integrate a speech synthesis system in the mobile app to convert detected gestures into audible voice output.
5. To ensure affordability and accessibility, making the device cost-effective compared to existing high-end solutions, which are often too expensive for widespread use.
6. To improve the social inclusion of disabled individuals by enabling them to communicate independently and interact confidently in society.
7. To develop a scalable and adaptable solution that can be enhanced with machine learning for improved gesture recognition and support multiple languages for broader usability.

CHAPTER-II

LITERATURE SURVEY

II.LITERATURE SURVEY

2.1

[1] Kshitij Kadam, Sakshi Telange, Krishna Yadav, Ashish Vishwakarma, "Helping Hand : A Glove for Mute People", Published in 2023 at International Journal for Research Trends and Innovation (IJRTI) | Volume 8, Issue 4 | ISSN: 2456-3315.

In today's world the number of deaf and dumb people is very large, so the problems that are faced by those people can't be neglected. The major problem for those disabled people is communication and that too with normal people who can speak. A smart glove for mute people is a revolutionary device that has been designed to help individuals who cannot communicate verbally. This device uses advanced technology to enable people to communicate effectively by converting sign language into spoken language. The smart glove is a wearable device that is equipped with sensors and software that can recognize hand gestures and movements. The sensors detect the movements made by the user's fingers, and the software translates those movements into words or phrases. The disabled peoples use a particular language called as sign language which is not understandable by normal people. So in order to eliminate this problem there is a need to develop a product that can convert sign language to voice and text output which will make communication for disabled people with normal people easier.

[2] Khushbu Pal, Pradnya Padmukh, Nidhi Patel, "Sign to Speech Smart Glove", Published at International Research Journal of Engineering and Technology (IRJET) Volume: 07 Issue: 02 | Feb 2020.

Every Normal human being sees, listens and then reacts to the situations by speaking himself out. But there are some human beings those who are not able to speak or listen, but they try to react through actions most of time normal people are not able to understand what they want to say. This application will help for both of them to communicate with each other. It consists of several parts, in part one with the help of hand gestures the signs will be detected by the sensors and the output will be given. Dumb people need to communicate with normal people for their daily routine or to express their emotions. The deaf-mute people throughout the world use sign language to communicate with other people. However, people who undergone from sign language training only they can communicate with another peoples. Sign language uses hand gestures and other means of non-verbal behaviors to convey their intended meaning It involves combining hand shapes, orientation and hand movements, arms or body movement, and facial expressions simultaneously, to fluidly express speaker's thoughts. The idea is to create a sign language to speech conversion system, using which the information gestured by a deaf-mute person can be effectively conveyed to a normal person. The main aim of this work is to design and implement a system to translate finger spelling (sign) to speech, using recognition and synthesis techniques.

[3] Khan Sohelrana, Syed Faiyaz Ahmed, Shaik Sameer, Ollepu Ashok, "A Review on Smart Gloves to Convert Sign to Speech for Mute Community" Published in 2020 at 8th International Conference on Reliability, Infocom Technologies and Optimization (Trends and Future Directions) (ICRITO) DOI: 10.1109/ICRITO48877.2020.9197947. The mute community all over the globe facing many problems while communicating. The normal and dumb people can communicate only in one way i.e. sign language, but many times communicating with normal persons they noticed difficulty. Therefore, there always exists communication barrier. This communication barrier is seen because a speech impaired person uses gesture to commune with common human being which is not suitable. We are implementing this project to reduce the barrier between dumb and normal person. This device design is based on the embedded system. Flex sensor and NodeMCU are the key components. The peoples who cannot able to speak they come across many problems while communicating with other persons. The speech impaired person uses sign language instead of speaking to represent themselves. Deaf persons can communicate only by using gestures. The significant drawback of sign language is that only the dumb person can understand gesture but not normal person. This gadget transforms gesture into speech i.e., gives voice to silent community who cannot speak.

2.2 Limitations, Problems And Scope

Limitations and problems:

This project in under testing and yet to be called fully functioning sign to voice converter and the biggest problem is the cost at which it is made. It is around 1 Lakh rupees which cannot be affordable for anyone. This project can eliminate the problem of dumb and deaf but to a certain extent with a high cost which cannot be affordable to all.

The biggest problem of the project are the components that are used are if high cost which cannot be acceptable. And the availability of the components at a large number is difficult and won't be easy to implement. As the main aim of the project is to help society and these projects cost a lot and wont be beneficial for society

Scope:

We went through all the projects and found the main problem of cost as all the project consisted of similar flex sensor which are at a high cost and are not at all applicable if we want to create help for society we have to eliminate the use of flex sensor which we did by introducing our own combinational circuit which is combination of resistors and metal contact plates which will be connected and disconnected according to the movement of the figures and will send signal to Arduino for further processing.

CHAPTER-III

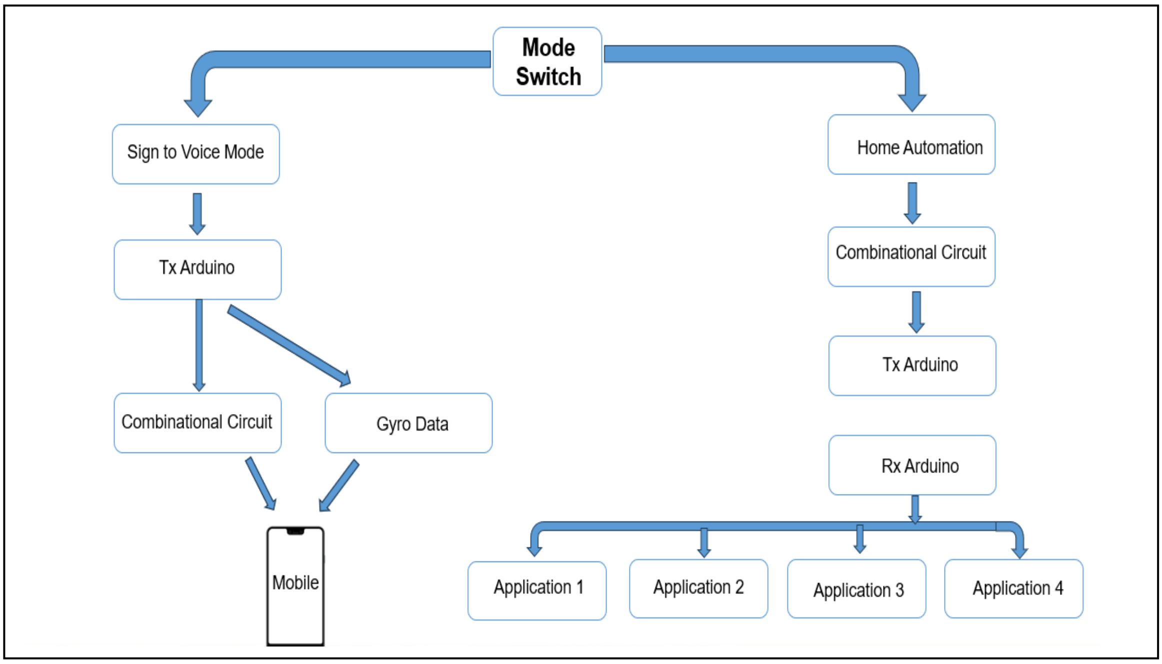
PROPOSED SYSTEM

III. PROPOSED SYSTEM

3.1 Introduction

- Gesture vocalizer is a project that can convert sign language to human voice. The main idea of creating this project is to convert sign language of dump and deaf people to understandable human voice available for everyone. Our society is so diversified and we have a community of dump and deaf people who want to communicate with us, want to convey their thoughts towards us but are unable to do so. Hence we came up with an idea of creating a sign to voice converter without using flex sensor.
- As the flex sensor cost 1000rs for 1 piece and using 5 can cost a lot and the whole project will definitely go very high and our main aim is to reduce the cost so that we can make things available for the society and encourage our dump and deaf community with us .
- This project will convert their sign language to human voice by using a combinational circuit of open and close contact and along with it. It will also have gyro sensor to measure the deflection in the motion of their hand. This data will further be processed by Arduino and via using Bluetooth module it will be available on our mobile devices and we will get the data as sound form.
- This project also has a home automation section which can be utilized using same gloves. This mode can be activated using a slider switch. We have connected 2 relay modules for ac devices and 2 dc source for motor and led interfaced to it.

3.2 Block Diagram



<u>Fig 5 : Block Diagram</u>

The Block Diagram represents a dual-mode system controlled by a Mode Switch, allowing users to select between two distinct functionalities: Sign to Voice Mode and Home Automation Mode.

1. **Sign to Voice Mode**

- Tx Arduino collects data from a sign recognition system.
- The data is processed through a combinational circuit and gyroscope (gyro) data is also considered.
- The processed data is sent to a mobile device, which likely converts sign gestures into voice output.

2. **Home Automation Mode**

- A combinational circuit processes input signals.
- Tx Arduino transmits the data to an Rx Arduino, enabling remote control.
- This system can interact with different applications (Application 1, 2, 3, 4), likely representing various home automation functions such as controlling lights, fans, or appliances.

Mode Switch allows users to toggle between sign-to-voice and home automation functionalities.

3.3 List of Components

SR NO.	COMPONENTS
1.	Arduino uno (2 pcs.)
2.	ADXL 345 accelerometer (1 pcs.)
3.	HC-05 Bluetooth Module (1pcs.)
4.	5v relay module (2 pcs)
5.	Rubber Glove (1 pcs.)
6.	Male to female, Male to Male, Female to Female Connecting wire (50 pcs.)
7.	Soldering Flux (1 pcs.)
8.	Glue stick (15 pcs.)
9.	1 k resistor (15 pcs.)
10.	Connecting Wire (5 m)
11.	1Amp Power Supply
12.	Nrf24l01 modules (2 pcs)
13.	Bo motor
14.	3.7v batteries and charging module
15.	Metal Contact plates
16.	Custom Application (Flutter, MIT, Andriod Studio)

3.4 Description of Components

3.4.1 Arduino Uno

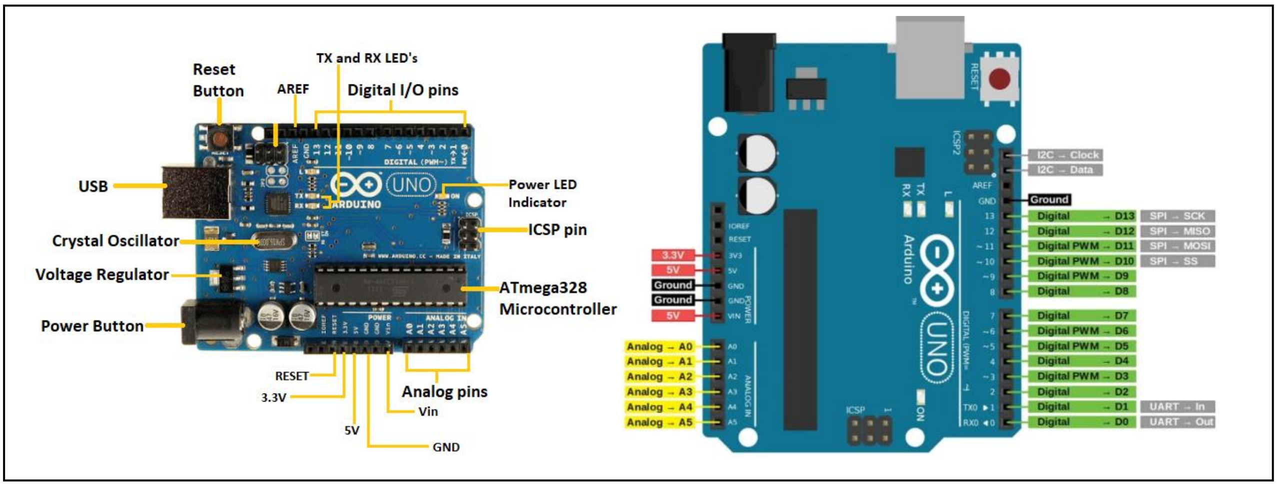


Fig 6 : Arduino Uno

Arduino Uno is a microcontroller board based on the ATmega328P (datasheet). It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz quartz crystal, a USB connection, a power jack, an ICSP header and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with an AC-to-DC adapter or battery to get started. You can tinker with your UNO without worrying too much about doing something wrong. The worst case scenario is that you would have to replace the chip and start again.

Arduino Uno Specification:

- Microcontroller: ATmega328P
- Operating Voltage: 5V
- Input Voltage (recommended): 7-12V
- Inout Voltage (limit): 6-20V
- Digital I/O Pins: 14 (of which 6 provide PWM output)
- PWM Digital I/O Pins: 6
- Analog Input Pins: 6
- DC Current per I/O Pin: 20 mA

- DC current for 3.3V Pin: 50 mA
- Flash Memory: 32 KB (ATmega328P) of which 0.5 KB used by bootloader
- SRAM: 2 KB (ATmega328P)
- EEPROM: 1 KB (ATmega328P)
- Clock Speed: 16 MHz
- LED_BUILTIN: 13
- Length: 68.6 mm
- Width: 58.4 mm
- Weight: 25 g

Powering up the Arduino Uno:

The **Arduino Uno** board can be powered via a USB connection or with an external power supply. The power source is selected automatically. External (non-USB) power can come either from an AC-to-DC adapter (wall-wart) or battery. The adapter can be connected by plugging a 2.1mm center-positive plug into the board's power jack. Leads from a battery can be inserted in the GND and Vin pin headers of the POWER connector. The board can operate on an external supply from 6 to 20 volts. If supplied with less than 7V, however, the 5V pin may supply less than five volts and the board may become unstable. If using more than 12V, the voltage regulator may overheat and damage the board. The recommended range is 7 to 12 volts.

The power pins are as follows:

- Vin: The input voltage to the Arduino/Genuino board when it's using an external power source (as opposed to 5 volts from the USB connection or other regulated power sources). You can supply voltage through this pin, or, if supplying voltage via the power jack, access it through this pin.
- 5V:This pin outputs a regulated 5V from the regulator on the board. The board can be supplied with power either from the DC power jack (7 - 12V), the USB connector (5V), or the VIN pin of the board (7-12V). Supplying voltage via the 5V or 3.3V pins bypasses the regulator, and can damage your board. We don't advise it.

- 3V3: A 3.3 volt supply generated by the on-board regulator. The maximum current draw is 50 mA.
- GND: Ground pins.
- IOREF: This pin on the Arduino/Genuino board provides the voltage reference with which the microcontroller operates. A properly configured shield can read the IOREF pin voltage and select the appropriate power source or enable voltage translators on the outputs to work with the 5V or 3.3V.

3.4.2 NRF24L01 Module

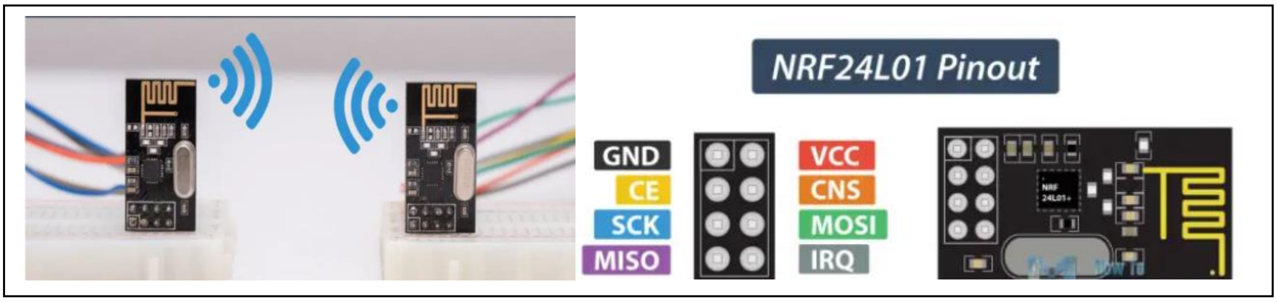


Fig 7 : NRF24L01

The NRF24L01 module is very popular choice for wireless communication when using Arduino. The nRF24L01 is a single chip 2.4GHz transceiver with an embedded baseband protocol engine (Enhanced ShockBurst™), designed for ultra low power wireless applications. The nRF24L01 is designed for operation in the world wide ISM frequency band at 2.400 - 2.4835GHz. An MCU (microcontroller) and very few external passive components are needed to design a radio system with the nRF24L01.

Key Features:

• Worldwide 2.4GHz ISM band operation

• Up to 2Mbps on air data rate

• Ultra low power operation

• 11.3mA TX at 0dBm output power

• 12.3mA RX at 2Mbps air data rate

• 900nA in power down
• 22µA in standby-I
• On chip voltage regulator
• 1.9 to 3.6V supply range
• Enhanced ShockBurst™
• Automatic packet handling
• Auto packet transaction handling
• 6 data pipe MultiCeiver™
• Air compatible with nRF2401A, 02, E1 and E2
• Low cost BOM
• ±60ppm 16MHz crystal
• 5V tolerant inputs
• Compact 20-pin 4x4mm QFN package

Applications:

• Wireless PC Peripherals
• Mouse, keyboards and remotes
• 3-in-one desktop bundles
• Advanced Media center remote controls
• VoIP headsets
• Game controllers
• Sports watches and sensors
• RF remote controls for consumer electronics
• Home and commercial automation
• Ultra low power sensor networks
• Active RFID
• Asset tracing systems
• Toys

Pin	Name	Pin function	Description
1	CE	Digital Input	Chip Enable Activates RX or TX mode
2	CSN	Digital Input	SPI Chip Select
3	SCK	Digital Input	SPI Clock
4	MOSI	Digital Input	SPI Slave Data Input
5	MISO	Digital Output	SPI Slave Data Output, with tri-state option
6	IRQ	Digital Output	Maskable interrupt pin
7	VDD	Power	Power Supply (+3V DC)
8	VSS	Power	Ground (0V)
9	XC2	Analog Output	Crystal Pin 2
10	XC1	Analog Input	Crystal Pin 1
11	VDD_PA	Power Output	Power Supply (+1.8V) to Power Amplifier
12	ANT1	RF	Antenna interface 1
13	ANT2	RF	Antenna interface 2
14	VSS	Power	Ground (0V)
15	VDD	Power	Power Supply (+3V DC)
16	IREF	Analog Input	Reference current
17	VSS	Power	Ground (0V)
18	VDD	Power	Power Supply (+3V DC)
19	DVDD	Power Output	Positive Digital Supply output for de-coupling purposes
20	VSS	Power	Ground (0V)

QUICK REFERENCE DATA

Parameter	Value	Unit
Minimum supply voltage	1.9	V
Maximum output power	0	dBm
Maximum data rate	2000	kbps
Supply current in TX mode @ 0dBm output power	11.3	mA
Supply current in RX mode @ 2000 kbps	12.3	mA
Temperature range	-40 to +85	°C
Sensitivity @ 1000 kbps	-85	dBm
Supply current in Power Down mode	900	nA

Type Number	Description	Version
nRF24L01	20 pin QFN 4x4, RoHS & SS-00259 compliant	D
nRF24L01 IC	Bare Dice	D
nRF24L01-EVKIT	Evaluation kit (2 test PCB, 2 configuration PCB, SW)	1.0

3.4.3 ADXL 345 Accelerometer

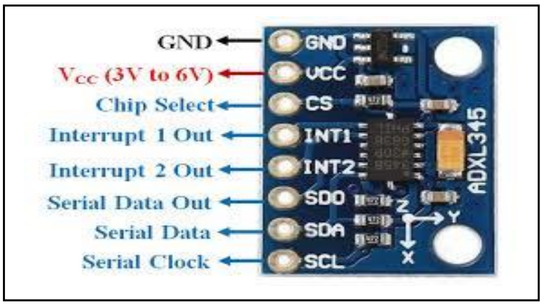


Fig 8 : Accelerometer Sensor

The ADXL345 is a low-power, 3-axis MEMS accelerometer modules with both I2C and SPI interfaces. The Adafruit Breakout boards for these modules feature on-board 3.3v voltage regulation and level shifting which makes them simple to interface with 5v microcontrollers such as the Arduino.

The ADXL345 features 4 sensitivity ranges from +/- 2G to +/- 16G. And it supports output data rates ranging from 10Hz to 3200Hz.suspension, traction control, and seat belt control. Many military applications like smart ammunition, flight control, etc. also make use of these sensors. In aerospace applications, these sensors are used for measuring microgravity and monitoring the movement and rotation of equipment/devices.

Each application requires an accelerometer or gyroscope with particular specifications. No one accelerometer or gyroscope sensor can fit all applications. These sensors are always used in some electronic control systems as mere values of acceleration and rotation of an object are of no use.

ADXL345 is a small 3-axis accelerometer that a dynamic range of +/-16g with 13-bit resolution, the maximum bandwidth of 3200Hz, and a maximum data transfer rate of 3200 times a second. It is a digital accelerometer sensor and outputs digital values of acceleration in three axes. The sensor outputs data formatted as 16-bit two’s complement that is accessible via SPI or I2C interfaces. This sensor is ultra-low power and consumes only 23 uA in measurement mode and 0.1 uA in standby mode.

ADXL345 has user-selectable resolution and measurement ranges that can be selected by passing serial commands to it. The sensor also supports flexible interrupt modes that can be mapped to either of its two interrupt pins. ADXL345 has several built-in sensing functions that can be mapped to the interrupt pins. Like, It has free-fall detection and tap detection functions. ADXL345 can detect the presence or lack of motion by comparing acceleration values to user-defined thresholds.

ADXL345 measures static acceleration due to gravity as well as dynamic acceleration resulting from motion or shock. The sensors come in a 14-lead LGA package having just 3mm x 5 mm x 1 mm dimensions. This sensor can be used in mobile device applications like mobile handsets, smartphones, gaming devices, pointing devices, personal navigation devices, hard drive protection, medical and industrial instrumentation.Understanding ADXL345 technical specification

The ADXL345 accelerometer sensor has the following technical specifications –

Measurement range – ADXL345 sensor can measure acceleration in three axes using a user-selectable range of +/-2g, +/-4g, +/-8g, and +/-16g. Higher is the measurement range, higher the acceleration an accelerometer can sense. With a measurement range of +/-2g selected, ADXL345 can measure acceleration up to 19.6 m/s2 (2 * 9.8 m/s) in either direction along each axis. With a measurement range of +/-16g selected, ADXL345 can measure acceleration up to 153.6 m/s2 (16 * 9.8 m/s) in either direction along each axis.

Output Resolution – ADXL345 supports output resolution of 10-bit for +/- 2g measurement range, 11-bit for +/- 4g, 12-bit for +/- 8g and 13-bit for +/- 16g. The default resolution is 10-bit for all measurement ranges.

Sensitivity – With the default resolution of 10-bit, the ADXL345 has typical sensitivity of 3.9 mg/LSB for default measurement range (i.e. +/- 2g), 7.8 mg/LSB for +/- 4g, 15.6 mg/LSB for +/- 8g and 31.2 mg/LSB for +/- 16g measurement range. This means that ADXL345 with default 10-bit resolution selected can detect minimum change of acceleration of 3.822 cm/s2 (3.9 * 9.8/1000 * 100) for +/- 2g, 7.64 cm/s2 for +/- 4g, 15.28 cm/s2 for +/- 8g, and 30.57 cm/s2 for +/- 16g range.

Output data rate and bandwidth – The output data rate and bandwidth of the sensor is selectable. The output data rate can range from 0.1 Hz (once in 10 seconds) to 3200 Hz (3200 times a second).

Operating voltage and current – The sensor requires an operating voltage of 2.5V that can range from 2.0V to 3.6V. It consumes approximately 30 uA for a data transfer rate less than 10 Hz and around 140 uA for data transfer rates above 100 Hz.

Operating temperature range – ADXL345 has an operating temperature range of -40˚C to +85˚C.

Maximum Ratings – ADXL345 can tolerate shock or acceleration up to 10,000 g (98 km/s2). It can tolerate voltage up to 3.9V and withstand temperature up to +105˚C.

3.4.4 HC- 05 Bluetooth module

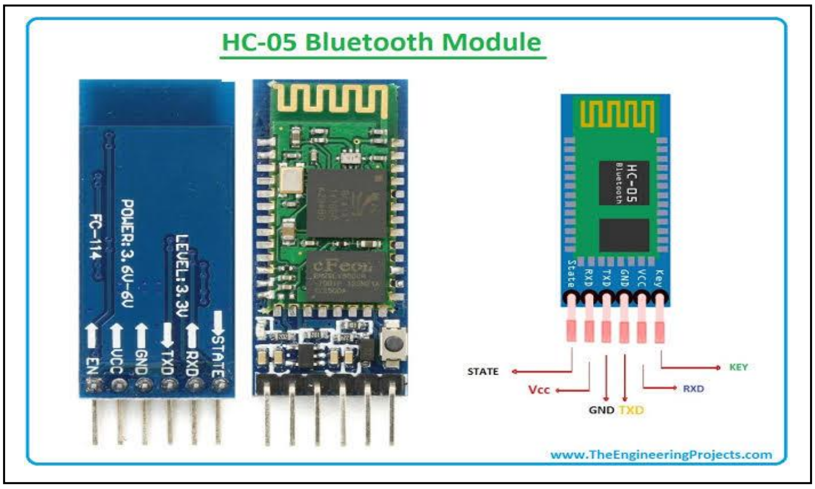


Fig 9: HC- 05 Bluetooth module

HC-05 module is an easy to use Bluetooth SPP(Serial Port Protocol) module, designed for transparent wireless serial connection setup. The HC-05 Bluetooth Module can be used in a Master or Slave configuration, making it a great solution for wireless communication. This serial port bluetooth module is fully qualified Bluetooth V2.0+EDR(Enhanced Data Rate)3Mbps Modulation with complete 2.4 GHz radio transceiver and baseband. It uses CSR Bluecore 04-External single chip Bluetooth system with CMOS technology and with AFH(Adaptive Frequency Hopping Feature).

The Bluetooth module HC-05 is a MASTER/SLAVE module.By default the factory setting is SLAVE. The Role of the module(Master or Slave) can be configured only by AT COMMANDS. The slave modules cannot initiate a connection to another Bluetooth device, but can accept connections. Master module can initiate a connection to other devices. The user can use it simply for a serial port replacement to establish connection between MCU and GPS, PC to your embedded project, etc.

Pin Description:

The HC-05 Bluetooth Module has 6pins. They are as follows:

● Enable: When enable is pulled LOW, the module is disabled which means the module will not turn on and it fails to communicate.When enable is left open or connected to 3.3V, the module is enabled i.e the module remains on and communication also takes place.

● Vcc: Supply Voltage 3.3V to 5V

● GND: Ground pin

● TXD & RXD: These two pins acts as an UART interface for communication

● State: It acts as a status indicator.When the module is not connected to paired with any other bluetooth device,signal goes Low.At this low state,the led flashes continuously which denotes that the module is not paired with other device.When this module is connected to/paired with any other bluetooth device,the signal goes High.At this high state,the led blinks with a constant delay say for example 2s delay which indicates that the module is paired.

● Button Switch: This is used to switch the module into AT command mode.To enable AT command mode,press the button switch for a second.With the help of AT commands,the user can change the parameters of this module but only when the module is not paired with any other BT device.If the module is connected to any other bluetooth device, it starts to communicate with that device and fails to work in AT command mode.

HC-05 Default Settings

● Default Bluetooth Name: HC-05

● Default Password: 1234 or 0000

● Default Communication: Slave

● Default Mode: Data Mode

● Data Mode Baud Rate: 9600, 8, N, 1

● Command Mode Baud Rate: 38400, 8, N, 1

● Default firmware: LINVOR

3.4.5 18650mAp Battery and Charger

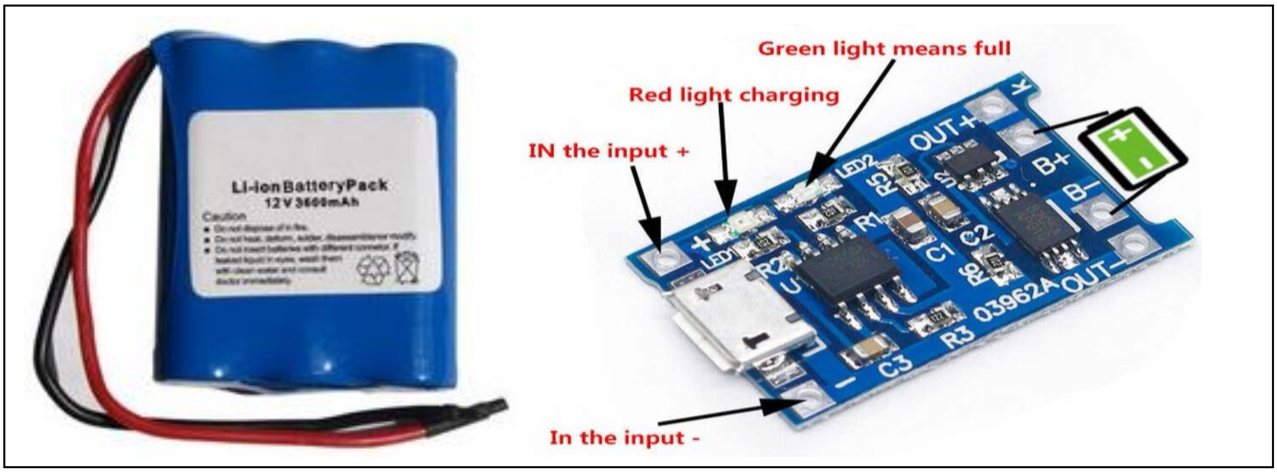


Fig 10 : Li-ion Battery

The 18650 battery is a Li-ion battery named after its 18mm × 65mm cylindrical size (diameter × height). When compared to AA size, it’s height and diameter both are larger. They are not replacements for AA or AAA size cells. The battery type 18650 are popular in rechargeable and high current draining devices considering its high-level capabilities like 250+ charge cycle and higher energy density.

The 18650 Li-ion battery due to its adaptability all around can be found in various fields, say, electric cars/ scooters, power banks, utility gadgets such as emergency lamps, torchlight, etc. Its safety property along with its high output current and energy capacity makes this battery popular among tech industries.

The 18650 battery specification includes its properties like the voltage, capacity, charge-discharge cycle, output current, output voltage and so on. This is a generalized specification of 18650 Li-ion battery, only properties marked with the remark of “Standard” are common to all 18650 batteries else not. This is to note that other properties such as capacity charge discharge cycles and capacity (mAh) are subjected to independent technologies to increase capability values to the consumers by doing research and development. All the 18650 specs are listed in table with detail.

18650 battery size / dimension:

- The Standard 18650 battery size is 18 ✕ 65mm.
- The 18650 battery length is 65mm.
- The diameter of the 18650 battery is 18mm.
- To be more precise, it has an approximate length of 65mm and an approximate diameter is

18mm but technically 18650 battery size is allowed with some tolerance in length and diameter.

- Thus you could find specification written as, (say) 18 ± 0.41mm ✕ 65 ± 0.25mm on datasheet and features of li-ion cell.

- Just remember 18 ✕ 65mm as a standard size, remaining things will be taken care of by designers and manufacturers of devices and batteries.
- The size of the 18650 battery is allowed for the reason that, various gadgets or devices inhibit different locally developed technologies. That might not able to manufacture exact precise length & diameter of either batteries or battery holding space, to fit the device or 18650 Lithium battery respectively.

3.4.6 5V Single-Channel Relay Module

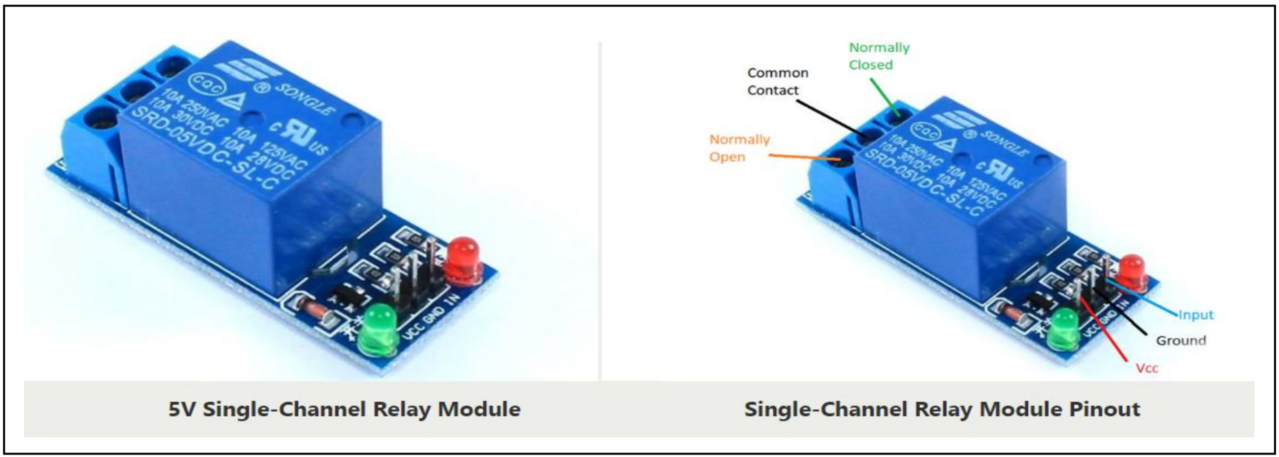


Fig 11 : Relay Module

Relay is an electromechanical device that uses an electric current to open or close the contacts of a switch. The single-channel relay module is much more than just a plain relay, it comprises of components that make switching and connection easier and act as indicators to show if the module is powered and if the relay is active or not.

Single-Channel Relay Module Specifications:

- Supply voltage – 3.75V to 6V

- Quiescent current: 2mA
- Current when the relay is active: ~70mA
- Relay maximum contact voltage – 250VAC or 30VDC
- Relay maximum current – 10A

Alternate Relay Modules:

Dual-channel relay module, four-channel relay module, 8-channel relay module.

Alternate Switching Modules:

Solid State Relay Module, TRIAC, SCR

Components Present on a 5V Single Channel Relay Module:

The following are the major components present on a relay module; we will get into the details later in this article.

5V Relay, Transistor, Diode, LEDs, Resistors, Male Header pins, 3-pin screw-type terminal connector, etc.

Single-Channel Relay Module Pin Description

Pin Number	Pin Name	Description
1	Relay Trigger	Input to activate the relay
2	Ground	0V reference
3	VCC	Supply input for powering the relay coil
4	Normally Open	Normally open terminal of the relay
5	Common	Common terminal of the relay
6	Normally Closed	Normally closed contact of the relay

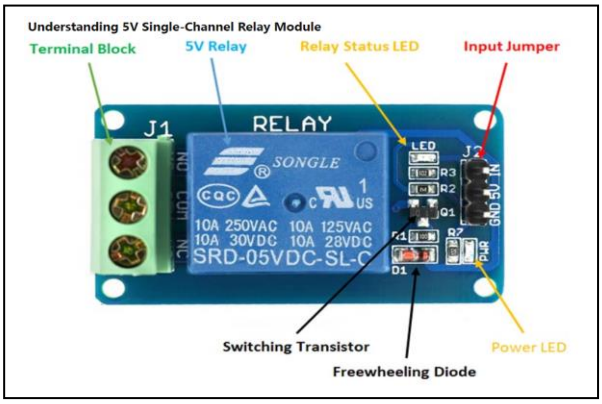


Fig 12 : Single-Channel Relay

The single-channel relay module is much more than just a plain relay, it contains components that make switching and connection easier and act as indicators to show if the module is powered and if the relay is active.

First is the screw terminal block. This is the part of the module that is in contact with mains so a reliable connection is needed. Adding screw terminals makes it easier to connect thick mains cables, which might be difficult to solder directly. The three connections on the terminal block are connected to the normally open, normally closed, and common terminals of the relay.

The second is the relay itself, which, in this case, is a blue plastic case. Lots of information can be gleaned from the markings on the relay itself. The part number of the relay on the bottom says “05VDC”, which means that the relay coil is activated at 5V minimum – any voltage lower than this will not be able to reliably close the contacts of the relay. There are also voltage and current markings, which represent the maximum voltage and current, the relay can switch. For example, the top left marking says “10A 250VAC”, which means the relay can switch a maximum load of 10A when connected to a 250V mains circuit. The bottom left rating says “10A 30VDC”, meaning the relay can switch a maximum current of 10A DC before the contacts get damaged.

The 'relay status LED' turns on whenever the relay is active and provides an indication of current flowing through the relay coil.

The input jumper is used to supply power to the relay coil and LEDs. The jumper also has the input pin, which when pulled high activates the relay.

The switching transistor takes an input that cannot supply enough current to directly drive the relay coil and amplifies it using the supply voltage to drive the relay coil. This way, the input can be driven from a microcontroller or sensor output. The freewheeling diode prevents voltage spikes when the relay is switched off.

How Does a Relay Work?

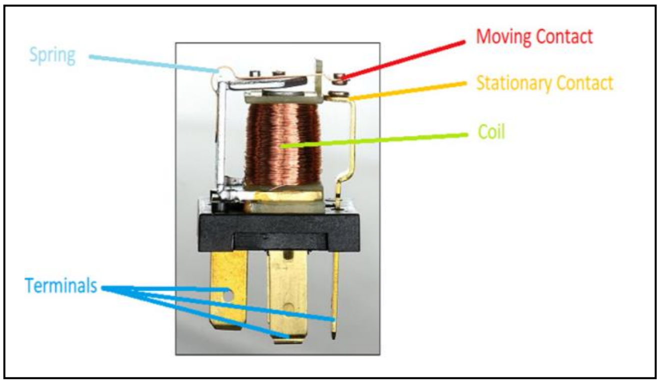


Fig 13 : Working of Relay

The relay uses an electric current to open or close the contacts of a switch. This is usually done using the help of a coil that attracts the contacts of a switch and pulls them together when activated, and a spring pushes them apart when the coil is not energized.

There are two advantages of this system – First, the current required to activate the relay is much smaller than the current that relay contacts are capable of switching, and second, the coil and the contacts are galvanically isolated, meaning there is no electrical connection between them. This means that the relay can be used to switch mains current through an isolated low voltage digital system like a microcontroller.

The extra components apart from the relay are there since it would not be possible to drive the relay directly from the pins of a microcontroller. digital logic or a sensor. This is because although the coil consumes much less current than the currents it can switch, it still needs relatively significant current – low power relays consume around 50mA while higher power relays consume around 500mA. The coil is also an inductive load, so when the coil is switched off, a large flyback voltage is developed which can damage the device turning it on and off. For this reason, a flyback diode is added anti-parallel to the relay coil to clamp the flyback voltage.

LEDs can be added to this basic circuit to act as indicators, and sometimes even optical isolation is added to the input to further improve the isolation.

3.3.7 Combinational Circuit

Fig 14: 1K Resistor

Fig 15 : Metal Slab

This are the components used in combinational along with connecting wire which will send 1 and 0 signal to aurdino and this will be used to create the function of Flex sensor. The working of combinational circuit is as following:-

- There are two pieces of metal used which are placed on the glove which are placed above joints of one figure and two connecting wire are taken out which goes via resistor to aurdino .
- When one of our figure is curled or straight accordingly metal plates are connected or de connected .
- Case1 :- When fingers are straight the metal plates are connected and aurdino is receving 1 and one code is getting excecuted according to sign language chart.
- Case2 :- when fingers are curled the metal plates are Disconnected and aurdino is receving 0 and is will be counted as 0 and accordingly code is transmitted and depending on sign lang chart data is transmitted to 16*2 lcd and by using HC05 module data is futher transmitted to mobile device.

3.10 Hardware Construction and Working

Construction:

At the TX end we have used combinational circuit along with ADXL 345 Gyro sensor which will be operating to generate signal language to signals which will be understandable for Arduino

and then via HC05 these signals will be transferred to mobile application.
Now for RX we have a combination of nrf with Arduino which will receive signals from tx Arduino and accordingly active corresponding appliances.

Working :

- Case1:- If there is a condition when first four fingers are curled and thumb is raised straight then Arduino gets the input signal as (00001) along with the deflection in the Gyro sensor if any movement is observed and according to both signal input is fed to Arduino.

- The input signal to Arduino is calibrated with the series of data streams that are fed during programming we can feed as many as signals, every signal will be corresponding to movement of fingers position and gyro position, introduction of gyro has increased the amount of data that can be processed and can be detected on the \application that we have created and converted as voice form.

- Case 2:- When we move the slider in either direction then home automation is activated and now nrf to nrf communication takes place. Where in when we bend one finger the corresponding appliance i.e (relay1, relay2, dc motor, led) turns on and off according to signals it has received.

CHAPTER-IV

IMPLEMENTATION

IV.IMPLEMENTATION

4.1 Introduction

The implementation of the smart glove-based assistive device involves integrating multiple hardware and software components to translate hand gestures into meaningful outputs, such as voice commands or control signals for smart applications. The system utilizes Arduino Uno, ADXL345 accelerometer, NRF24L01 wireless module, and HC-05 Bluetooth module to detect, process, and transmit gestures for different functionalities.

The implementation process consists of the following key steps:

- Combinational circuit and ADXL 345 is used as input to Arduino and output is produced on Mobile via HC05 it is is given as output using mobile application
- According to movement in fingers the output of combinational is produced and with calibration of ADXL 345 gyro sensor a combined output is produced and this output is fed as input to aurdino for further processing and producing output mobile device.
- The processing of input is done and according to the curled finger and position of gyro the output is produced which will be further explained this output is then further produced as output mobile device in form of sound.
- The data that is transferred from aurdino is via HC05 and with help of application that is connected via Bluetooth module which is interfaced aurdino. This data is then read as text to speech and then heard as sound.
- The second part of the project is home automation which can be triggered using slider switch. Which then transfers the data via nrf module to other Arduino connection where in relay modules and other components are connected.
- There are many ways to create a application we went through Android studio, and found application to be difficult to handle as we dint had much prior knowledge of installation and operation of software. We went through many tutorial videos our guide to helped us a lot but things where not easy as we felt. Then we moved to flutter.
- Working with flutter was pretty less complicated as android studio, we went through creating the application but had problem with connecting HC05 with application it had some undetectable problem as is was not compatible. So we had to shift to MIT app inventor.

- Working with MIT was easy as it has many facility working as pick and place and removed many problems we faced before in many other applications. It is never that Android studio or flutter were bad. It was we who were unable to operate. Currently we are working with MIT and soon will be able to complete the work with ease.

4.2 Circuit Diagram

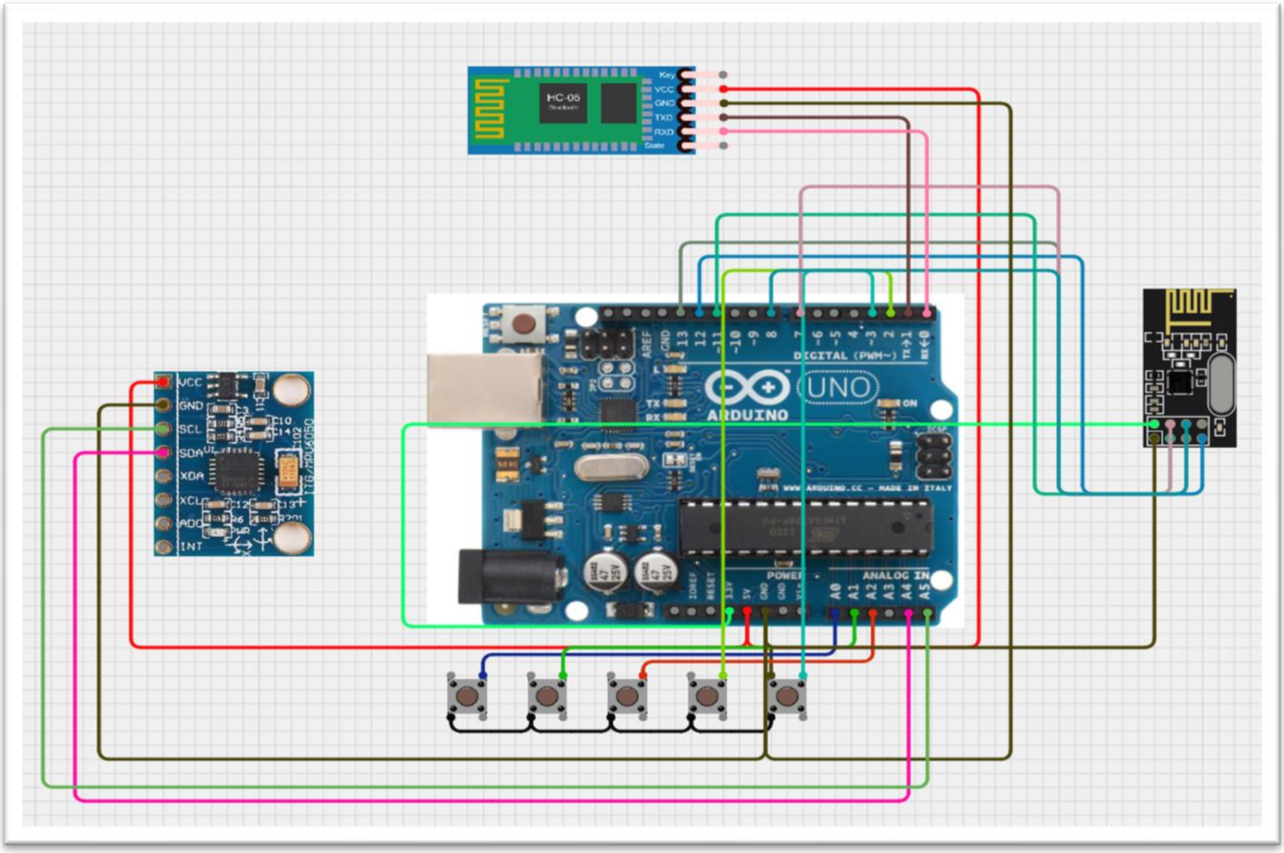


Fig 16 : TX Circuit Diagram

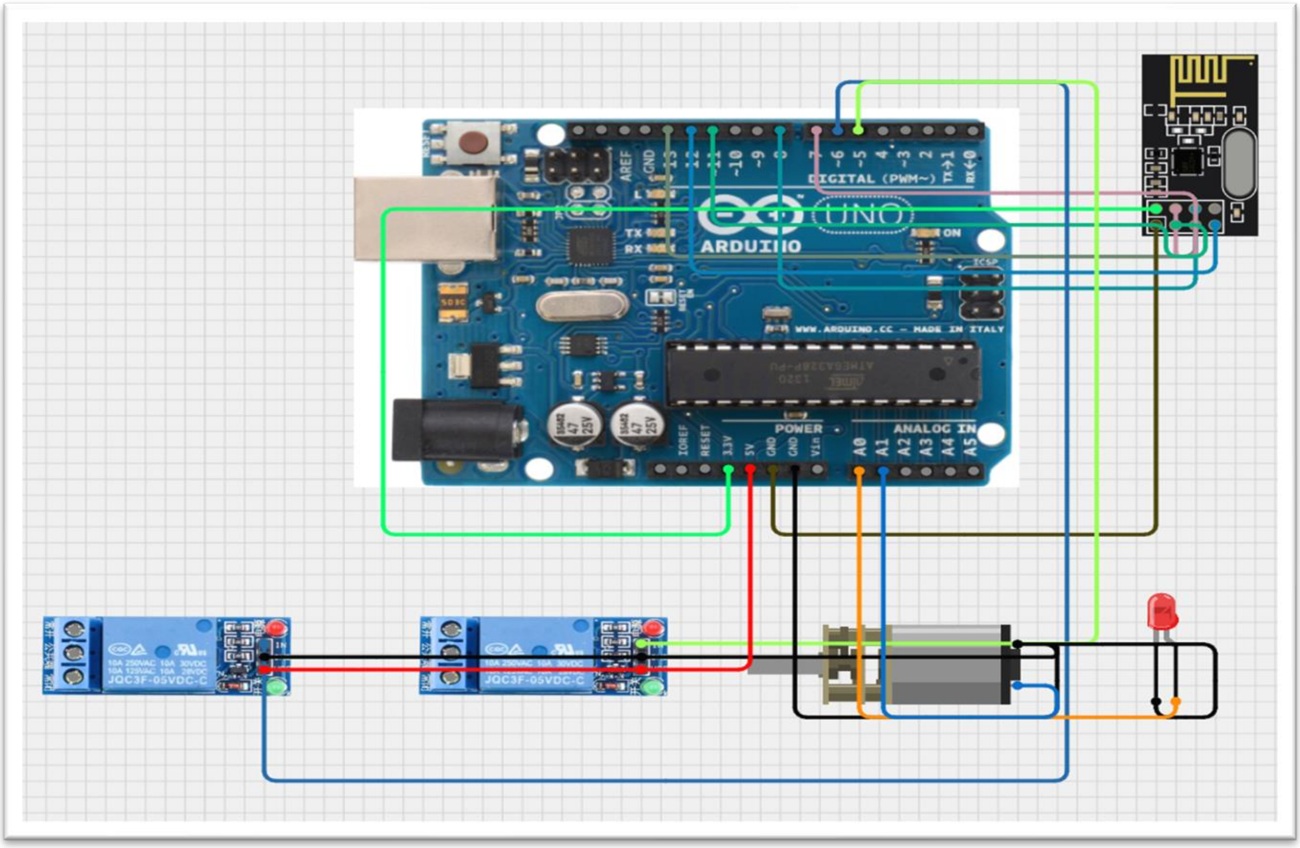
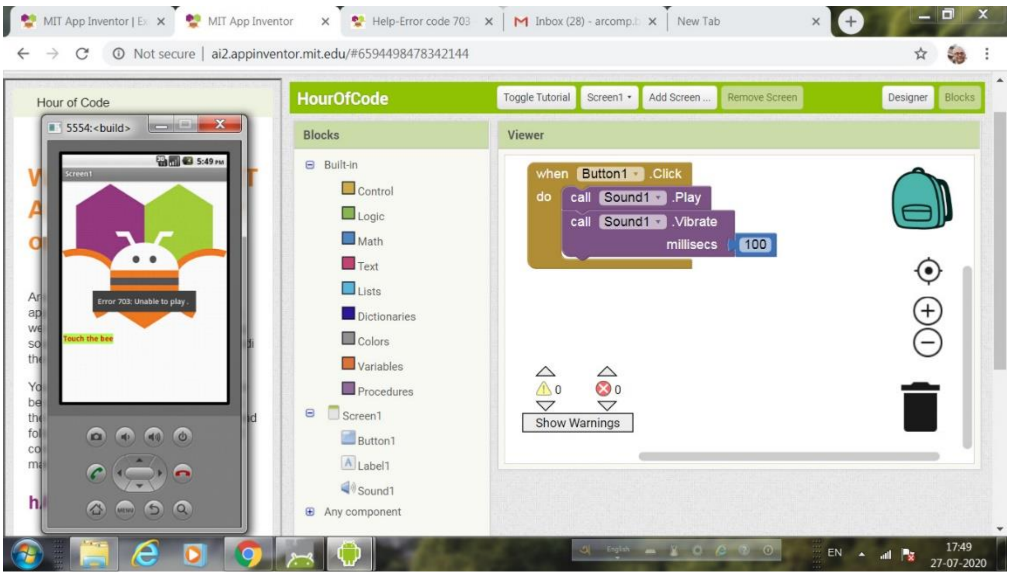


Fig 17 : RX Circuit Diagram

4.3 Mobile Application Implementation

MIT App Inventor



In recent years the internet has reached a large number of people across the world. And this has motivated all the people who own some businesses or people who want to connect to a large number of people to use and make mobile/laptop applications. These applications provide the customer with a way of easily exploring the content of the provider and it helps the provider with an ample opportunity to present their content more efficiently then they could when they were using websites. But not all people can make the applications. They require some medium to get their business on an application or an app. One way is to hire app developers. It can prove to be costly for some new business setters or the businessmen can be living in some remote part of the country where app developers are not present. Hence, to make app development easier MIT provides us with the MIT app inventor. This is a platform that makes app development easy for anyone who knows to code or not.

Steps to use MIT App Inventor

Step 1: Open a Gmail account in case you don't have one.

Step 2: Open the link https://appinventor.mit.edu/ and log in to your Gmail account.

Step 3: You need to install the App Inventor Companion App(MIT AI2 Companion) on our mobile device that helps in live testing of our application.

Step 4: We need to connect both mobile devices & laptops/desktop should be connected to the same WiFi network.

Step 5: To start the app-building click on "Start New Project"

Step 6: To connect your mobile device, choose "Connect" and "AI Companion" from the top menu.

Step 7: Now to connect the MIT AI2 App on your device and desktop/laptop scan the QR code or type the 6 digit code which is appearing on your PC screen.

Step 8: Now you can see the app you are building on your device.

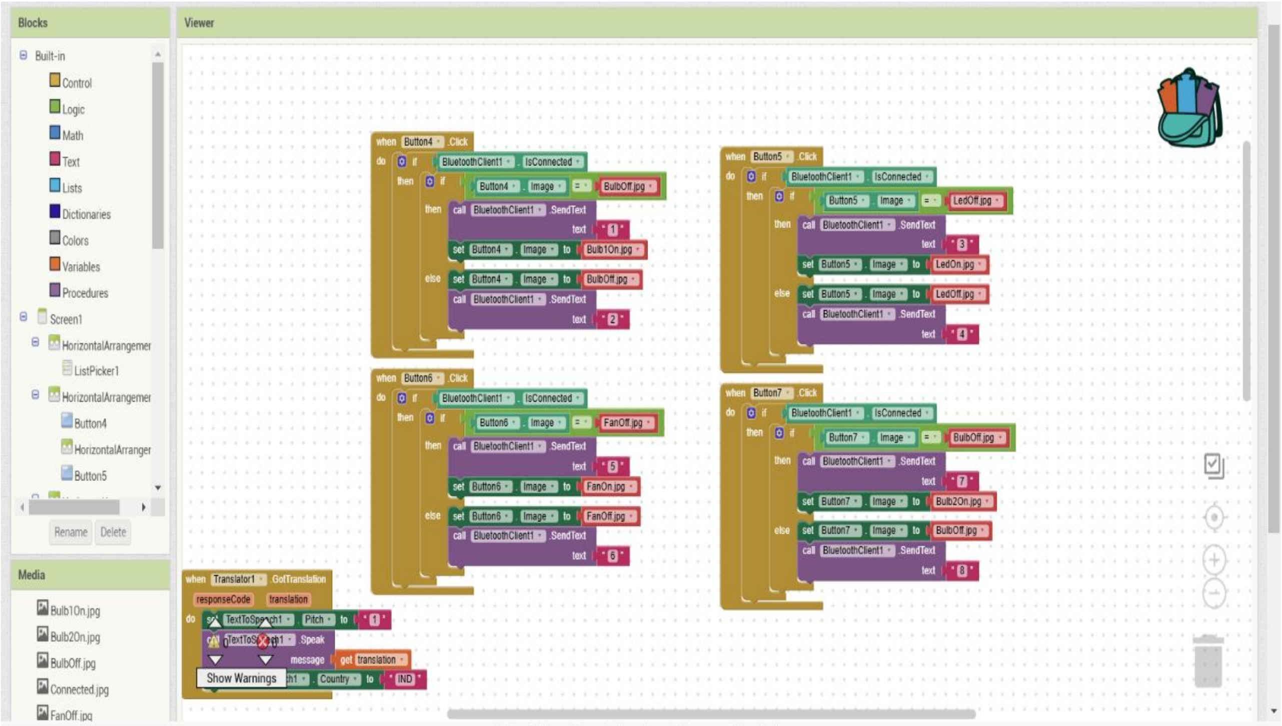
5.3.2 Benefits of MIT App Inventor

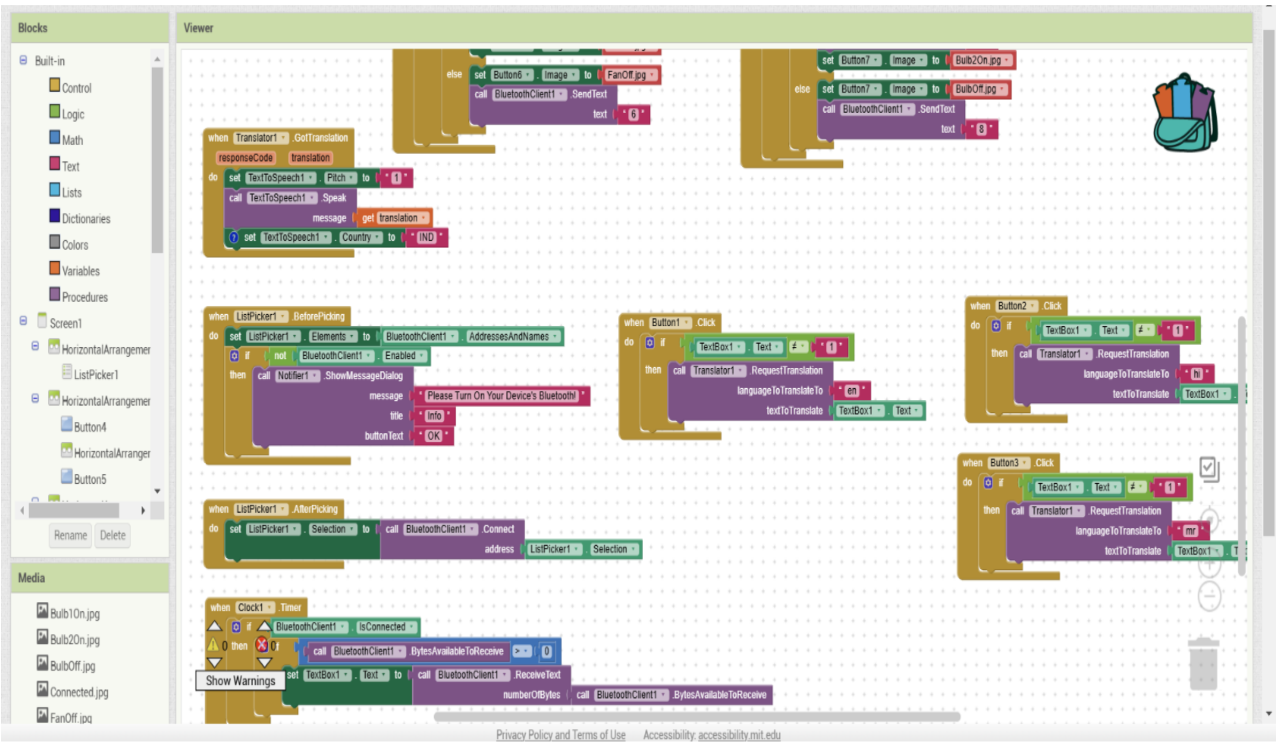
● Everything is done through a select and drop manner. This means we can select a particular chunk of code and drop in our code. Hence, no typing.

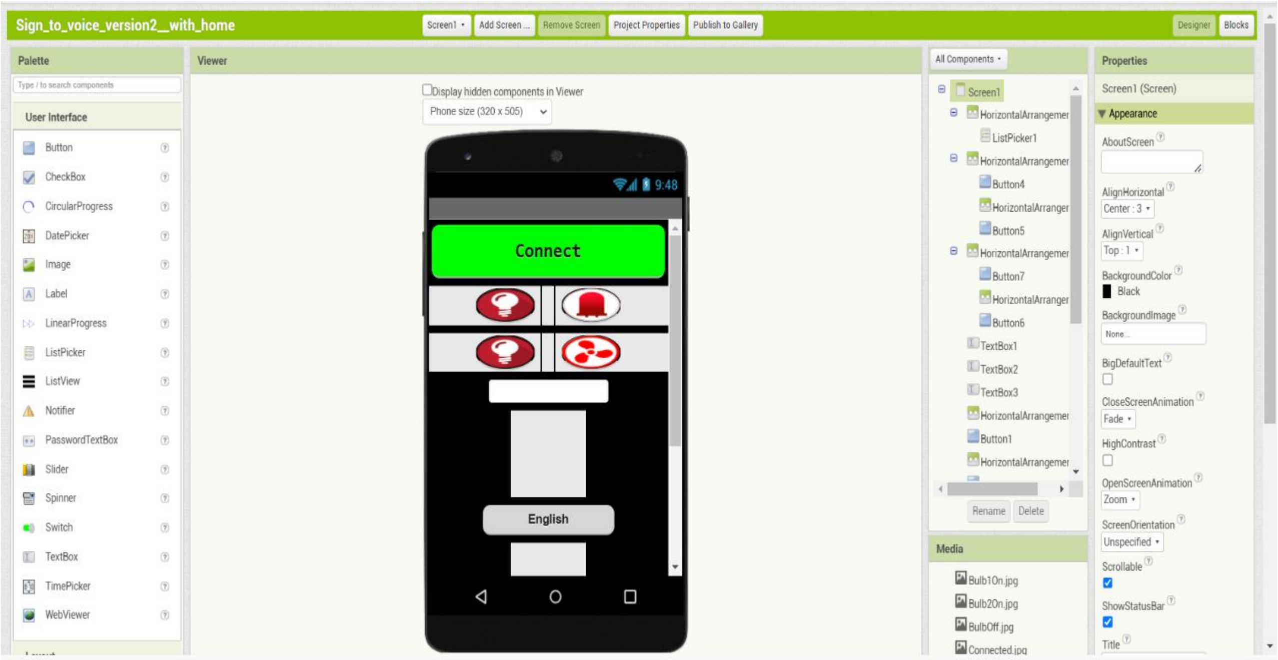
● Easy to test your app. We can check the app developed on desktop or laptop with the app inventor application on our mobile phones.

● MIT provides the user with some basic lessons which help in building that apps and that helps in a proper understanding of how the MIT app inventor platform works for the user.

● Power of native apps with a simple UI.


Blocks
Viewer
Built-in
Control
Logic
Math
Text
Lists
Dictionaries
Colors
Variables
Procedures
Screen1
ListPicker1
Button4
Button5
Rename
Delete
Media
Bulb1On.jpg
Bulb2On.jpg
BulbOff.jpg
Connected.jpg
Show Warnings


Blocks
Viewer
Built-in
Control
Logic
Math
Text
Lists
Dictionaries
Colors
Variables
Procedures
Screen1
ListPicker1
Button4
Button5
Rename
Delete
Media
Bulb1On.jpg
Bulb2On.jpg
BulbOff.jpg
Connected.jpg
Show Warnings
Privacy Policy and Terms of Use
Accessibility: accessibility.mit.edu



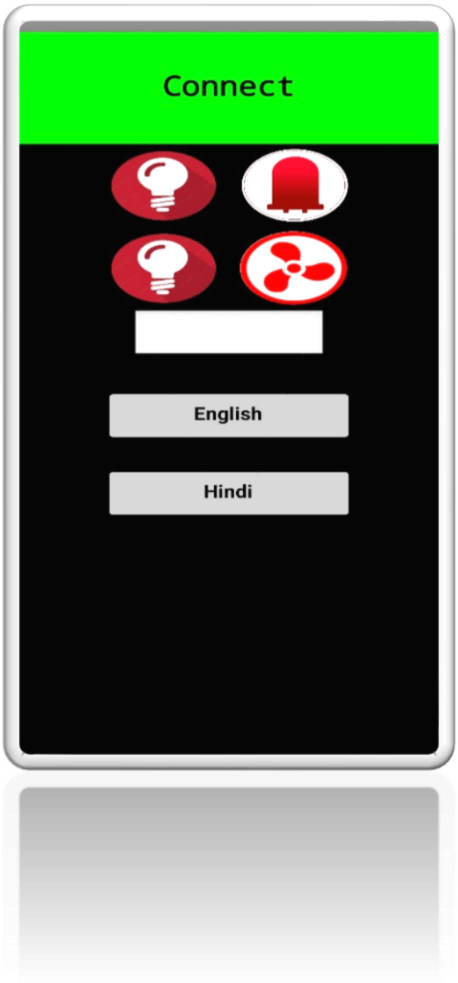


Fig 18: This is how the App looks like

Advantage:

1)Easy to use and Simple Circuits.
2)We can upgrade the project with many other sign language.
3)Use of Pic Controller will reduce the Size of project.
4)Being a prototype project looks complex but when will be implemented at last scale will definitely be more cost effective and small in size.

Disadvantage:

1) Prototype Size and Cost is high.
2) Coding Complexity will increase with more Upgradeability.

4.4 Software Implementation

The software implementation of the smart glove-based assistive device involves programming the Arduino Uno using the Arduino IDE to process sensor data, recognize gestures, and communicate with external devices. The programming is done in C/C++ using Arduino libraries to interface with the ADXL345 accelerometer, NRF24L01 transceiver, and HC-05 Bluetooth module.

1. Programming Environment & Tools:

- Software Used: Arduino IDE
- Programming Language: C/C++
- Libraries Used:
  - Wire.h – For I2C communication with ADXL345
  - SPI.h & RF24.h – For NRF24L01 wireless communication
  - SoftwareSerial.h – For Bluetooth communication with HC-05

2. Code Implementation Stages:
A. Gesture Data Collection from ADXL345

- The ADXL345 accelerometer provides X, Y, and Z-axis acceleration values, which are read via I2C communication.
- The data is processed to detect specific hand movements and finger gestures.

B. Wireless Data Transmission via NRF24L01

- The processed gesture data is transmitted wirelessly using the NRF24L01 transceiver module.

C. Bluetooth Communication with HC-05

- If the smart glove is in Sign-to-Voice mode, it transmits gesture data to a mobile app via Bluetooth.

3. Mode Switching Mechanism

- The system includes a mode switch that allows users to toggle between Sign-to-Voice mode and Home Automation mode.

4. Smart Home Control via Receiver Arduino

- The receiver Arduino connected to home appliances receives data from NRF24L01 and performs actions based on detected gestures.

5. Testing & Calibration

- The system is tested by mapping gestures to specific voice outputs or home automation commands.
- Calibration of ADXL345 sensitivity ensures accurate gesture recognition.
- Fine-tuning of **wireless communication** parameters enhances data transmission reliability.

4.5 Main Program:

4.5.1 TX Code (Arduino on Glove):

```
#include "Wire.h"
#include "I2Cdev.h"
#include "MPU6050.h"


#include <LiquidCrystal.h>

#include <SPI.h>
#include <nRF24L01.h>
#include <RF24.h>

RF24 radio(11, 12); // CE, CSN

const byte address[6] = "00011";

int msg[5]; //Total number of data to be sent (data package)

int led1, led2, rly1, rly2 , led1flag, led2flag, rly1flag, rly2flag;


LiquidCrystal lcd(25, 23, 25, 27, 29, 28);


const int buttonPin1 = 4;
const int buttonPin2 = 3;
const int buttonPin3 = A4;
const int buttonPin4 = A2;
const int buttonPin5 = A1;

const int homeswitch = A3;
```

```
//3pulse , 4dht 5slider

int buttonStatus1 = 0;
int buttonStatus2 = 0;
int buttonStatus3 = 0;
int buttonStatus4 = 0;
int buttonStatus5 = 0;


int currentBPM = 0;


//APP STRINGS

char value;

//SINGLE

String f1 = "I need Food";
String f2 = "I need Water";
String f3 = "I am a boy";
String f4 = "let us play";
String f5 = "How are you";


//DOUBLE

String d12 = "Who are you?";
String d13 = "I dont know";
String d14 = "Where are you?";
String d15 = "Who was he";

String d23 = "It is working";
String d24 = "next";
String d25 = "India is my country";

String d34 = "Good job";
String d35 = "Nice work";

String d45 = "Get me a taxi";
```

```
//TRIPPLE

String t123 = "Where are you?";
String t134 = "Call mom!";
String t145 = "I know him";
String t124 = "My cat";
String t125 = "My Dog";
String t135 = "I am Sorry";

String t234 = "Get me that";
String t245 = "Are you ok";
String t235 = "I am a student";

String t345 = "Give me book";


//TETRA
String t1234 = "Beautiful";
String t1345 = "Nice car";
String t1245 = "Mobile Phone";
String t1235 = "Let us study";


//PENTA

String t12345 = "ALERT";

int modeflag = 0;

//GYRO

// String status1 = "Hi";

MPU6050 mpu;
int16_t ax, ay;
int16_t gx, gy;

struct MyData {
  byte X;
  byte Y;
};

MyData data;
```

```
void setup() {

  Wire.begin();
  radio.begin();

  radio.openWritingPipe(address);

  radio.stopListening();


  pinMode(buttonPin1, INPUT_PULLUP);
  pinMode(buttonPin2, INPUT_PULLUP);
  pinMode(buttonPin3, INPUT_PULLUP);
  pinMode(buttonPin4, INPUT_PULLUP);
  pinMode(buttonPin5, INPUT_PULLUP);

  pinMode(Modeswitch,INPUT_PULLUP);  /// just keeping it uncommented so that no need to
eliminate it from all fingers gestures in this version

  pinMode(homeswitch,INPUT_PULLUP);


}

void loop() {


  mpu.getMotion6(&ax, &ay, &az, &gx, &gy, &gz);
  data.X = map(ax, -17000, 17000, 0, 255);  // X axis data
  data.Y = map(ay, -17000, 17000, 0, 255);  // Y axis data
  // delay(500);


  if (data.Y < 20) {  //gesture : down

    Serial.println("Hello. How are you");

  }
  if (data.Y > 145) {  //gesture : up

    Serial.println("Call an ambulance");

  }
  if (data.X > 155) {  //gesture : left
```

```
    Serial.println("I need Help");

  }
  if (data.X < 80) {  //gesture : right

    Serial.println("good morning");

    }


  // currentBPM = pulseSensor.getBeatsPerMinute();

  buttonStatus1 = digitalRead(buttonPin1);
  buttonStatus2 = digitalRead(buttonPin2);
  buttonStatus3 = digitalRead(buttonPin3);
  buttonStatus4 = digitalRead(buttonPin4);
  buttonStatus5 = digitalRead(buttonPin5);


if (Serial.available() > 0) {


       value = Serial.read();
       Serial.println(value);

  //FOR USING HOME AUTOMATON FROM APP

      if (value == '6')  {
      led1 = 1;

      }
      else if (value == '2')  {
      led1 = 0;
      }
       else if (value == '3')  {
      led2 = 1;
      }
       else if (value == '4')  {
      led2 = 0;
      }
      else if (value == '5')  {
      rly1 = 1;
      }
```

```
      else if (value == '2')  {
      rly1 = 0;
      }
       else if (value == '7')  {
      rly2 = 1;
      }
      else if (value == '8')  {
      rly2 = 0;
      }


  }

////////////////////////////////////////////////RF GESTURES/////

  if (digitalRead(homeswitch) == LOW)     // GLOVES WORK FOR HOME AUTMATION
  {

    if (buttonStatus1 == HIGH && buttonStatus2 == HIGH && buttonStatus3 == HIGH &&
buttonStatus4 == HIGH && buttonStatus5 == HIGH && led1flag == 0 )
   {
     if(led1 == 0)
     {
       led1 = 1;
     }

     else
     {
       led1 = 0;
     }

     led1flag = 1;
   }
    if (buttonStatus1 == HIGH && buttonStatus2 == HIGH && buttonStatus3 == HIGH &&
buttonStatus4 == HIGH && buttonStatus5 == HIGH && led1flag == 1 )
   {
     led1flag = 0;
   }
//////////////////////////////////////////////////////////

     if (buttonStatus1 == HIGH && buttonStatus2 == LOW && buttonStatus3 == HIGH &&
buttonStatus4 == HIGH && buttonStatus5 == HIGH && led2flag == 0 )
   {
     if(led2 == 0)
```

```
    {
      led2 = 1;
    }
    else
    {
      led2 = 0;
    }

    led2flag = 1;

  }
     if (buttonStatus1 == HIGH && buttonStatus2 == HIGH && buttonStatus3 == HIGH &&
buttonStatus4 == HIGH && buttonStatus5 == HIGH && led2flag == 1 )
  {
    led2flag = 0;
  }

//////////////////////////////////////////////////////////////////////////////



   if (buttonStatus1 == HIGH && buttonStatus2 == HIGH && buttonStatus3 == LOW &&
buttonStatus4 == HIGH && buttonStatus5 == HIGH && rly1flag == 0 )
  {
    if(rly1 == 0)
    {
      rly1 = 1;
    }

    else
    {
      rly1 = 0;
    }

    rly1flag = 1;

  }
   if (buttonStatus1 == HIGH && buttonStatus2 == HIGH && buttonStatus3 == HIGH &&
buttonStatus4 == HIGH && buttonStatus5 == HIGH && rly1flag == 1 )
  {
     rly1flag = 0;
  }
////////////////////////////////////////////////////////////////////////////////////////////////
```

```
    if (buttonStatus1 == HIGH && buttonStatus2 == HIGH && buttonStatus3 == HIGH &&
buttonStatus4 == LOW && buttonStatus5 == HIGH && rly2flag == 0 )
   {
     if(rly2 == 0)
     {
       rly2 = 1;
     }

     else
     {
       rly2 = 0;
     }

     rly2flag = 1;

   }

   if (buttonStatus1 == HIGH && buttonStatus2 == HIGH && buttonStatus3 == HIGH &&
buttonStatus4 == HIGH && buttonStatus5 == HIGH && rly2flag == 1)
   {
     rly2flag = 0;
   }

  }

    // RF DATA TRANSMISSION
    msg[0] = led1;
    msg[1] = led2;
    msg[2] = rly1;
    msg[3] = rly2;

    radio.write(msg, sizeof(msg));

// delay(55);

///////////////////////////////////////
if (buttonStatus1 == HIGH && buttonStatus2 == HIGH && buttonStatus3 == HIGH &&
buttonStatus4 == HIGH && buttonStatus5 == HIGH ) {

//  lcd.clear();
//    Serial.print("BPM: ");
    Serial.println(currentBPM);
   delay(501);
```

```
}
///////////////////////////////////////////////////////////////////////////////////////////////////////////////

 if (digitalRead(homeswitch) == HIGH)     // STOP TRANSMITING RF DATA AND GLOVES
WORK AS NORMAL
  {

     ///SINGLES

  if (buttonStatus1 == LOW && buttonStatus2 == HIGH && buttonStatus3 == HIGH &&
buttonStatus4 == HIGH && buttonStatus5 == HIGH && digitalRead(Modeswitch)== HIGH) {

    lcd.clear();
    Serial.println(f1);
    if (strlen(f1.c_str()) > 16) {
    // print the first 11 characters on the first line
//    lcd.setCursor(0, 0);
//    lcd.print(f1.substring(0, 16));

    // print the remaining characters on the second line
//    lcd.setCursor(0, 1);
//    lcd.print(f1.substring(16));
  }

  else {
    // if the string is 11 characters or less, print it on the first line
//    lcd.setCursor(0, 0);
//    lcd.print(f1);
  }
    delay(1111);


  }



  if (buttonStatus1 == HIGH && buttonStatus2 == LOW && buttonStatus3 == HIGH &&
buttonStatus4 == HIGH && buttonStatus5 == HIGH && digitalRead(Modeswitch)== HIGH)


    delay(1111);

  }
```

```
  if (buttonStatus1 == HIGH && buttonStatus2 == HIGH && buttonStatus3 == LOW &&
buttonStatus4 == HIGH && buttonStatus5 == HIGH && digitalRead(Modeswitch)== HIGH)
    delay(1111);
  }

  if (buttonStatus1 == HIGH && buttonStatus2 == HIGH && buttonStatus3 == HIGH &&
buttonStatus4 == LOW && buttonStatus5 == HIGH && digitalRead(Modeswitch)== HIGH)

  {
    lcd.clear();
    Serial.println(f4);
    if (strlen(f4.c_str()) > 16) {
      }

    delay(1111);
    //    cnt = 0;
  }


  if (buttonStatus1 == HIGH && buttonStatus2 == HIGH && buttonStatus3 == HIGH &&
buttonStatus4 == HIGH && buttonStatus5 == LOW && digitalRead(Modeswitch)== HIGH)

  {
    lcd.clear();
    Serial.println(f5);
   if (strlen(f5.c_str()) > 16) {
  }

    delay(1111);

  }


  /////DOUBLE FINGERS


  if (buttonStatus1 == LOW && buttonStatus2 == LOW && buttonStatus3 == HIGH &&
buttonStatus4 == HIGH && buttonStatus5 == HIGH && digitalRead(Modeswitch)== HIGH)

  {
    lcd.clear();
    Serial.println(d12);
    if (strlen(d12.c_str()) > 16) {
  } else {
```

```
    // if the string is 11 characters or less, print it on the first line
//    lcd.setCursor(0, 0);
//    lcd.print(d12);
  }
    delay(1111);


  }

  if (buttonStatus1 == LOW && buttonStatus2 == HIGH && buttonStatus3 == LOW &&
buttonStatus4 == HIGH && buttonStatus5 == HIGH && digitalRead(Modeswitch)== HIGH)

  {
    lcd.clear();
    Serial.println(d13);
    if (strlen(d13.c_str()) > 16) {

  }

    delay(1111);

  }
  //
  if (buttonStatus1 == LOW && buttonStatus2 == HIGH && buttonStatus3 == HIGH &&
buttonStatus4 == LOW && buttonStatus5 == HIGH && digitalRead(Modeswitch)== HIGH)

  {
    lcd.clear();
    Serial.println(d14);
    if (strlen(d14.c_str()) > 16) {
    // print the first 11 characters on the first line
    lcd.setCursor(0, 0);
    lcd.print(d14.substring(0, 16));

    // print the remaining characters on the second line
    lcd.setCursor(0, 1);
    lcd.print(d14.substring(16));
  } else {
    // if the string is 11 characters or less, print it on the first line
    lcd.setCursor(0, 0);
    lcd.print(d14);
  }

    delay(1111);
```

```
  }


  if (buttonStatus1 == LOW && buttonStatus2 == HIGH && buttonStatus3 == HIGH &&
buttonStatus4 == HIGH && buttonStatus5 == LOW && digitalRead(Modeswitch)== HIGH)

  {
    lcd.clear();
    Serial.println(d15);
   if (strlen(d15.c_str()) > 16) {

    lcd.print(d15);
  }

    delay(1111);

  }

  if (buttonStatus1 == HIGH && buttonStatus2 == LOW && buttonStatus3 == LOW &&
buttonStatus4 == HIGH && buttonStatus5 == HIGH && digitalRead(Modeswitch)== HIGH)

  {
    lcd.clear();
    Serial.println(d23);
    if (strlen(d23.c_str()) > 16) {
    // print the first 11 characters on the first line
    lcd.setCursor(0, 0);
    lcd.print(d23.substring(0, 16));

    // print the remaining characters on the second line
    lcd.setCursor(0, 1);
    lcd.print(d23.substring(16));
  } else {
    // if the string is 11 characters or less, print it on the first line
    lcd.setCursor(0, 0);
    lcd.print(d23);
  }

    delay(1111);

  }

  if (buttonStatus1 == HIGH && buttonStatus2 == LOW && buttonStatus3 == HIGH &&
```

```
buttonStatus4 == LOW && buttonStatus5 == HIGH && digitalRead(Modeswitch)== HIGH)

  {
   lcd.clear();
   Serial.println(d24);
   if (strlen(d24.c_str()) > 16) {
   // print the first 11 characters on the first line
   lcd.setCursor(0, 0);
   lcd.print(d24.substring(0, 16));

   // print the remaining characters on the second line
   lcd.setCursor(0, 1);
   lcd.print(d24.substring(16));
  } else {
   // if the string is 11 characters or less, print it on the first line
   lcd.setCursor(0, 0);
   lcd.print(d24);
  }

   delay(1111);
 //    cnt = 0;
  }


  if (buttonStatus1 == HIGH && buttonStatus2 == LOW && buttonStatus3 == HIGH &&
buttonStatus4 == HIGH && buttonStatus5 == LOW && digitalRead(Modeswitch)== HIGH)

  {
   lcd.clear();
   Serial.println(d25);
   if (strlen(d25.c_str()) > 16) {
   // print the first 11 characters on the first line
   lcd.setCursor(0, 0);
   lcd.print(d25.substring(0, 16));

   // print the remaining characters on the second line
   lcd.setCursor(0, 1);
   lcd.print(d25.substring(16));
  } else {
   // if the string is 11 characters or less, print it on the first line
   lcd.setCursor(0, 0);
   lcd.print(d25);
  }
```

```
    delay(1111);

  }
  if (buttonStatus1 == HIGH && buttonStatus2 == HIGH && buttonStatus3 == LOW &&
buttonStatus4 == LOW && buttonStatus5 == HIGH && digitalRead(Modeswitch)== HIGH)

  {
    lcd.clear();
    Serial.println(d34);
    if (strlen(d34.c_str()) > 16) {
    // print the first 11 characters on the first line
    lcd.setCursor(0, 0);
    lcd.print(d34.substring(0, 16));

    // print the remaining characters on the second line
    lcd.setCursor(0, 1);
    lcd.print(d34.substring(16));
  } else {
    // if the string is 11 characters or less, print it on the first line
    lcd.setCursor(0, 0);
    lcd.print(d34);
  }



    delay(1111);

  }

  if (buttonStatus1 == HIGH && buttonStatus2 == HIGH && buttonStatus3 == LOW &&
buttonStatus4 == HIGH && buttonStatus5 == LOW && digitalRead(Modeswitch)== HIGH)

  {
    lcd.clear();
    Serial.println(d35);
    if (strlen(d35.c_str()) > 16) {
    // print the first 11 characters on the first line
    lcd.setCursor(0, 0);
    lcd.print(d35.substring(0, 16));

    // print the remaining characters on the second line
    lcd.setCursor(0, 1);
    lcd.print(d35.substring(16));
  } else {
```

```
    // if the string is 11 characters or less, print it on the first line
    lcd.setCursor(0, 0);
    lcd.print(d35);
  }

    delay(1111);

  }

  if (buttonStatus1 == HIGH && buttonStatus2 == HIGH && buttonStatus3 == HIGH &&
buttonStatus4 == LOW && buttonStatus5 == LOW && digitalRead(Modeswitch)== HIGH)

  {
    lcd.clear();
    Serial.println(d45);
    if (strlen(d45.c_str()) > 16) {
    // print the first 11 characters on the first line
    lcd.setCursor(0, 0);
    lcd.print(d45.substring(0, 16));

    // print the remaining characters on the second line
    lcd.setCursor(0, 1);
    lcd.print(d45.substring(16));
  } else {
    // if the string is 11 characters or less, print it on the first line
    lcd.setCursor(0, 0);
    lcd.print(d45);
  }



    delay(1111);

  }

  //Serial.println("LOOP");

  /////TRIPLE FINGERS


  if (buttonStatus1 == LOW && buttonStatus2 == LOW && buttonStatus3 == LOW &&
buttonStatus4 == HIGH && buttonStatus5 == HIGH && digitalRead(Modeswitch)== HIGH)

  {
```

```
    lcd.clear();
    Serial.println(t123);
    if (strlen(t123.c_str()) > 16) {
    // print the first 11 characters on the first line
    lcd.setCursor(0, 0);
    lcd.print(t123.substring(0, 16));

    // print the remaining characters on the second line
    lcd.setCursor(0, 1);
    lcd.print(t123.substring(16));
  } else {
    // if the string is 11 characters or less, print it on the first line
    lcd.setCursor(0, 0);
    lcd.print(t123);
  }

    delay(1111);

  }

  if (buttonStatus1 == LOW && buttonStatus2 == HIGH && buttonStatus3 == LOW &&
buttonStatus4 == LOW && buttonStatus5 == HIGH && digitalRead(Modeswitch)== HIGH)

  {
    lcd.clear();
    Serial.println(t134);
    if (strlen(t134.c_str()) > 16) {
    // print the first 11 characters on the first line
    lcd.setCursor(0, 0);
    lcd.print(t134.substring(0, 16));

    // print the remaining characters on the second line
    lcd.setCursor(0, 1);
    lcd.print(t134.substring(16));
  } else {
    // if the string is 11 characters or less, print it on the first line
    lcd.setCursor(0, 0);
    lcd.print(t134);
  }

    delay(1111);
  }
  //
  if (buttonStatus1 == LOW && buttonStatus2 == HIGH && buttonStatus3 == HIGH &&
```

```
buttonStatus4 == LOW && buttonStatus5 == LOW && digitalRead(Modeswitch)== HIGH)

  {
   lcd.clear();
   Serial.println(t145);
   if (strlen(t145.c_str()) > 16) {
   // print the first 11 characters on the first line
   lcd.setCursor(0, 0);
   lcd.print(t145.substring(0, 16));

   // print the remaining characters on the second line
   lcd.setCursor(0, 1);
   lcd.print(t145.substring(16));
  } else {
   // if the string is 11 characters or less, print it on the first line
   lcd.setCursor(0, 0);
   lcd.print(t145);
  }

   delay(1111);
  }


  if (buttonStatus1 == LOW && buttonStatus2 == LOW && buttonStatus3 == HIGH &&
buttonStatus4 == LOW && buttonStatus5 == HIGH && digitalRead(Modeswitch)== HIGH)

  {
   lcd.clear();
   Serial.println(t124);
   if (strlen(t124.c_str()) > 16) {
   // print the first 11 characters on the first line
   lcd.setCursor(0, 0);
   lcd.print(t124.substring(0, 16));

   // print the remaining characters on the second line
   lcd.setCursor(0, 1);
   lcd.print(t124.substring(16));
  } else {
   // if the string is 11 characters or less, print it on the first line
   lcd.setCursor(0, 0);
   lcd.print(t124);
  }

   delay(1111);
```

```
  }



  if (buttonStatus1 == LOW && buttonStatus2 == LOW && buttonStatus3 == HIGH &&
buttonStatus4 == HIGH && buttonStatus5 == LOW && digitalRead(Modeswitch)== HIGH)

  {
   lcd.clear();
   Serial.println(t125);
    if (strlen(t125.c_str()) > 16) {
   // print the first 11 characters on the first line
   lcd.setCursor(0, 0);
   lcd.print(t125.substring(0, 16));

   // print the remaining characters on the second line
   lcd.setCursor(0, 1);
   lcd.print(t125.substring(16));
  } else {
   // if the string is 11 characters or less, print it on the first line
   lcd.setCursor(0, 0);
   lcd.print(t125);
  }

   delay(1111);
  }

  if (buttonStatus1 == LOW && buttonStatus2 == HIGH && buttonStatus3 == LOW &&
buttonStatus4 == HIGH && buttonStatus5 == LOW && digitalRead(Modeswitch)== HIGH)

  {
   lcd.clear();
   Serial.println(t135);
    if (strlen(t135.c_str()) > 16) {
   // print the first 11 characters on the first line
   lcd.setCursor(0, 0);
   lcd.print(t135.substring(0, 16));

   // print the remaining characters on the second line
   lcd.setCursor(0, 1);
   lcd.print(t135.substring(16));
  } else {
   // if the string is 11 characters or less, print it on the first line
   lcd.setCursor(0, 0);
```

```
  lcd.print(t135);
 }

  delay(1111);
 }

 if (buttonStatus1 == HIGH && buttonStatus2 == LOW && buttonStatus3 == LOW &&
buttonStatus4 == LOW && buttonStatus5 == HIGH && digitalRead(Modeswitch)== HIGH)

 {
  lcd.clear();
  Serial.println(t234);
   if (strlen(t234.c_str()) > 16) {
  // print the first 11 characters on the first line
  lcd.setCursor(0, 0);
  lcd.print(t234.substring(0, 16));

  // print the remaining characters on the second line
  lcd.setCursor(0, 1);
  lcd.print(t234.substring(16));
 } else {
  // if the string is 11 characters or less, print it on the first line
  lcd.setCursor(0, 0);
  lcd.print(t234);
 }


  delay(1111);
 }


 if (buttonStatus1 == HIGH && buttonStatus2 == LOW && buttonStatus3 == HIGH &&
buttonStatus4 == LOW && buttonStatus5 == LOW && digitalRead(Modeswitch)== HIGH)

 {
  lcd.clear();
  Serial.println(t245);
    if (strlen(t245.c_str()) > 16) {
  // print the first 11 characters on the first line
  lcd.setCursor(0, 0);
  lcd.print(t245.substring(0, 16));

  // print the remaining characters on the second line
  lcd.setCursor(0, 1);
```

```
    lcd.print(t245.substring(16));
  } else {
    // if the string is 11 characters or less, print it on the first line
    lcd.setCursor(0, 0);
    lcd.print(t245);
  }

    delay(1111);
  }

  if (buttonStatus1 == HIGH && buttonStatus2 == LOW && buttonStatus3 == LOW &&
buttonStatus4 == HIGH && buttonStatus5 == LOW && digitalRead(Modeswitch)== HIGH)

  {
    lcd.clear();
    Serial.println(t235);
       if (strlen(t235.c_str()) > 16) {
    // print the first 11 characters on the first line
    lcd.setCursor(0, 0);
    lcd.print(t235.substring(0, 16));

    // print the remaining characters on the second line
    lcd.setCursor(0, 1);
    lcd.print(t235.substring(16));
  } else {
    // if the string is 11 characters or less, print it on the first line
    lcd.setCursor(0, 0);
    lcd.print(t235);
  }

    delay(1111);
  }

  if (buttonStatus1 == HIGH && buttonStatus2 == HIGH && buttonStatus3 == LOW &&
buttonStatus4 == LOW && buttonStatus5 == LOW && digitalRead(Modeswitch)== HIGH)

  {
    lcd.clear();
    Serial.println(t345);
        if (strlen(t345.c_str()) > 16) {
    // print the first 11 characters on the first line
    lcd.setCursor(0, 0);
    lcd.print(t345.substring(0, 16));
```

```
    // print the remaining characters on the second line
    lcd.setCursor(0, 1);
    lcd.print(t345.substring(16));
  } else {
    // if the string is 11 characters or less, print it on the first line
    lcd.setCursor(0, 0);
    lcd.print(t345);
  }

    delay(1111);
  }


//TETRA
//
if (buttonStatus1 == LOW && buttonStatus2 == LOW && buttonStatus3 == LOW &&
buttonStatus4 == LOW && buttonStatus5 == HIGH && digitalRead(Modeswitch)== HIGH)

 {
   lcd.clear();
   Serial.println(t1234);
        if (strlen(t1234.c_str()) > 16) {
   // print the first 11 characters on the first line
   lcd.setCursor(0, 0);
   lcd.print(t1234.substring(0, 16));

   // print the remaining characters on the second line
   lcd.setCursor(0, 1);
   lcd.print(t1234.substring(16));
 } else {
   // if the string is 11 characters or less, print it on the first line
   lcd.setCursor(0, 0);
   lcd.print(t1234);
 }

   delay(1111);
 }

 if (buttonStatus1 == LOW && buttonStatus2 == HIGH && buttonStatus3 == LOW &&
buttonStatus4 == LOW && buttonStatus5 == LOW && digitalRead(Modeswitch)== HIGH)

 {
   lcd.clear();
   Serial.println(t1345);
```

```
      if (strlen(t1345.c_str()) > 16) {
  // print the first 11 characters on the first line
  lcd.setCursor(0, 0);
  lcd.print(t1345.substring(0, 16));

  // print the remaining characters on the second line
  lcd.setCursor(0, 1);
  lcd.print(t1345.substring(16));
 } else {
  // if the string is 11 characters or less, print it on the first line
  lcd.setCursor(0, 0);
  lcd.print(t1345);
 }
  delay(1111);
 }


 if (buttonStatus1 == LOW && buttonStatus2 == LOW && buttonStatus3 == HIGH &&
buttonStatus4 == LOW && buttonStatus5 == LOW && digitalRead(Modeswitch)== HIGH)

 {
  lcd.clear();
  Serial.println(t1245);
      if (strlen(t1245.c_str()) > 16) {
  // print the first 11 characters on the first line
  lcd.setCursor(0, 0);
  lcd.print(t1245.substring(0, 16));

  // print the remaining characters on the second line
  lcd.setCursor(0, 1);
  lcd.print(t1245.substring(16));
 } else {
  // if the string is 11 characters or less, print it on the first line
  lcd.setCursor(0, 0);
  lcd.print(t1245);
 }

  delay(1111);
 }

 if (buttonStatus1 == LOW && buttonStatus2 == LOW && buttonStatus3 == LOW &&
buttonStatus4 == HIGH && buttonStatus5 == LOW && digitalRead(Modeswitch)== HIGH)

 {
```

```
  lcd.clear();
  Serial.println(t1235);
       if (strlen(t1235.c_str()) > 16) {
  // print the first 11 characters on the first line
  lcd.setCursor(0, 0);
  lcd.print(t1235.substring(0, 16));

  // print the remaining characters on the second line
  lcd.setCursor(0, 1);
  lcd.print(t1235.substring(16));
 } else {
  // if the string is 11 characters or less, print it on the first line
  lcd.setCursor(0, 0);
  lcd.print(t1235);
 }

  delay(1111);
 }


 //PENTA

 if (buttonStatus1 == LOW && buttonStatus2 == LOW && buttonStatus3 == LOW &&
buttonStatus4 == LOW && buttonStatus5 == LOW && digitalRead(Modeswitch)== HIGH)
  {
//    lcd.clear();
    Serial.println(t12345);
         if (strlen(t12345.c_str()) > 16) {
    // print the first 11 characters on the first line
//    lcd.setCursor(0, 0);
//    lcd.print(t12345.substring(0, 16));

    // print the remaining characters on the second line
//    lcd.setCursor(0, 1);
//    lcd.print(t12345.substring(16));
  } else {
    // if the string is 11 characters or less, print it on the first line
//    lcd.setCursor(0, 0);
//    lcd.print(t12345);
  }
    delay(1111);
  }
}
}
```

4.5.2 RX code (Arduino for Home Automation):

```
#include <SPI.h>
#include <nRF24L01.h>
#include <RF24.h>


RF24 radio(8, 7); // CE, CSN

const byte address[6] = "00001";

int msg[4]; //Total number of data to be sent (data package)

const int led1 =6;
const int Fan = 3;
const int rly1 = 4;
const int rly2 = 5;

void setup() {
  // put your setup code here, to run once:


  pinMode(rly1,OUTPUT);

  pinMode(rly2,OUTPUT);

  pinMode(led1, OUTPUT);
 pinMode(Fan, OUTPUT);


    Serial.begin(9600);

  radio.begin();

  radio.startListening();


}

void loop() {
  // put your main code here, to run repeatedly:


  if(radio.available()){
```

```
  bool done = false;

// while (!done){
// done = radio.read(msg, sizeof(msg));

radio.read(msg, sizeof(msg));

//Serial.println(sizeof(msg));
// Serial.println(msg[0]);
// Serial.println(msg[1]);

}


    if (msg[0] ==2 ) //led1on
    {


       digitalWrite(led1,HIGH);
// Serial.println("led 1 ON ");

    }

    if (msg[0] == 0 ) //led1off
    {


       digitalWrite(led1,LOW);
//Serial.println("led 1 OFF ");

    }


    if (msg[1] == 1 ) //led2on
    {


       digitalWrite(Fan,HIGH);

//      Serial.println("Fan On ");
    }

    if (msg[1] == 0 ) //led2off
    {
```

```
     digitalWrite(Fan,LOW);
//Serial.println("fan OFF ");

    }


    if (msg[2] == 1 ) //rly1on
    {


      digitalWrite(rly1,LOW);

//      Serial.println("relay1 on ");
    }

    if (msg[2] == 0 ) //rly1off
    {


      digitalWrite(rly1,HIGH);

//      Serial.println("relay1 OFF ");
    }


    if (msg[3] == 1 ) //rly2on
    {


      digitalWrite(rly2,LOW);
// Serial.println("relay2 on ");

    }

    if (msg[3] == 0 ) //rly2off
    {


      digitalWrite(rly2,HIGH);
// Serial.println("relay2 OFF ");

    }
}
```

CHAPTER-V
CONCLUSION AND FUTURE SCOPE

V.CONCLUSION & FUTURE SCOPE

5.1 Conclusion

The smart glove-based assistive device developed in this project successfully enables paralyzed individuals to control external devices using hand gestures. By integrating an **Arduino Uno, NRF24L01 module, Bluetooth module HC-05, and ADXL345 accelerometer**, the system effectively converts finger and hand movements into wireless signals that are transmitted to a mobile app. This approach enhances accessibility and provides an intuitive means of communication and control for individuals with motor impairments. The project demonstrates the feasibility of gesture-based assistive technology and its potential to improve the quality of life for users with limited mobility.

5.2 Future Scope

1. Integration with IoT and AI – The system can be enhanced by integrating IoT (Internet of Things) to enable remote monitoring and AI-based gesture recognition for improved accuracy.
2. Enhanced Signal Processing – Implementing machine learning algorithms can improve gesture recognition accuracy and adaptability to different users.
3. Expansion of Control Functions – The device can be extended to control smart home appliances, wheelchairs, or robotic arms for greater independence.
4. Compact and Wearable Design – Miniaturization of hardware and use of flexible sensors can make the glove more comfortable and user-friendly.
5. Haptic Feedback and Voice Assistance – Adding haptic feedback or voice-based assistance can provide real-time confirmation to users, making the device more interactive.
6. Cloud-Based Data Storage – Storing gesture data in the cloud can enable customization and user-specific adaptability, allowing for personalized responses.
7. Medical Applications – The glove can be expanded for physiotherapy and rehabilitation, helping patients recover hand mobility through guided exercises.

This project lays a strong foundation for further research in gesture-based assistive technologies, paving the way for more advanced, accessible, and efficient solutions for individuals with disabilities.

5.3 Applications

The smart glove project has diverse applications in various fields, enhancing accessibility, communication, and automation. Below are some key applications:

1. Assistive Technology for Speech-Impaired Individuals
- Converts hand gestures into speech using a mobile application via Bluetooth.
- Helps people with speech and hearing disabilities communicate effectively.
- Provides real-time voice output for better social interaction.

2. Smart Home Automation
- Allows users to control home appliances using simple hand gestures.
- Can turn lights, fans, and electronic devices ON/OFF via wireless communication.
- Increases accessibility for elderly and differently-abled individuals.

3. Rehabilitation & Physiotherapy
- Tracks hand and finger movements for post-stroke rehabilitation.
- Helps doctors monitor muscle movement and recovery progress in patients.
- Can be used for physical therapy exercises for patients with motor impairments.

4. Industrial and Robotic Control
- Provides gesture-based control of robotic arms and industrial machinery.
- Enhances human-machine interaction in manufacturing and automation.
- Reduces physical strain and increases efficiency in hazardous environments.

5. Virtual Reality (VR) and Gaming
- Enhances gaming experience by using gesture-based interactions.
- Can be integrated into VR systems for immersive gameplay.
- Enables hand-tracking applications in augmented reality (AR).

6. Military and Defense Applications
- Can be used in gesture-controlled drones and robotic systems.
- Facilitates silent communication for military personnel in strategic operations.
- Enables hands-free control of tactical equipment.

7. Wearable Technology & Smart Devices
- Can be used in smart wearables for gesture-based input and controls.
- Enables interaction with smartphones, smart TVs, and IoT devices without physical contact.
- Enhances accessibility and convenience in modern technology.

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[2] Khushbu Pal, Pradnya Padmukh, Nidhi Patel. Sign to Speech Smart Glove. Published on: 2nd Feb, 2020 At International Research Journal of Engineering and Technology. (IRJET)

[3] Khan Sohelrana, Syed Faiyaz Ahmed, Shaik Sameer, Ollepu Ashok. A Review on Smart Gloves to convert Sign to Speech for Mute Community. Published on: 4th June 2020 At International Conference on Reliability, Infocom Technologies and Optimization(ICRITO).

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APPENDICES

1.Publication

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SMART GOLVE TO CONVERT GESTURES TO SPEECH AND HOME AUTOMATION

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ABSTRACT

This project focuses on developing a Smart Glove that converts hand gestures into speech, enabling effective communication for individuals with paralysis or speech impairments. The glove integrates an ADXL345 accelerometer and Combinational Circuit to detect hand movements, with an Arduino Uno processing the data. Signals are transmitted via an NRF24L01 wireless module or Bluetooth HC-05 to a mobile application, which generates speech output.

Designed to be affordable, portable, and user-friendly, this assistive device bridges the communication gap, particularly benefiting underprivileged areas. Future improvements may include machine learning-based gesture recognition and multi-language support for enhanced usability. Unlike costly existing solutions, this system offers an accessible and practical alternative, fostering social inclusion and improving the quality of life for individuals with disabilities.

Keywords: Smart Glove, Gesture-To-Speech, Assistive Technology, Arduino, Wireless Communication, Cost-Effective.

I. INTRODUCTION

In an information-oriented society, all members of the Society have the right to obtain and use the information. Therefore, it is necessary to develop various devices, which can provide information to anyone easily. More than 15.4 million people worldwide were living with a spinal cord injury (SCI) and with other Physically challenged people like visually impaired or deaf-blind people are facing lots of problems while communicating or interacting with other people. To provide a helping hand towards the paralysed society, recent technological growth has been developing different skilled methods to enhance their communication procedures. Illiteracy among this group is very high, much of which is attributed due to the lack of reading material in accessible format. For reading and writing dumb and deaf people always use Sign language representation of different alphabets, symbols and digits etc. Sign language is the language used by the Dumb and deaf to read and write. It is vital for communication and educational purposes. But normal people face problem to understand the sign language. So, this device can help people to communicate easily with the injured of paralysed people.

NEED

Communication is a fundamental human right, yet millions of speech-impaired and paralyzed individuals struggle to express themselves due to physical limitations. Traditional sign language, though effective, is not universally understood, creating a significant communication gap between dumb, deaf, and paralyzed individuals and the rest of society. This leads to social isolation, dependency, and reduced opportunities in education, employment, and daily interactions.

Existing assistive devices, such as gesture recognition systems and speech-generating devices, are often expensive and inaccessible in developing countries like India, where affordability plays a crucial role in adoption. High-cost solutions (e.g., projects exceeding ₹2 lakh) are not feasible for mass deployment, leaving a large portion of the affected population without adequate support. Additionally, many rural areas lack access to computers and advanced technologies, making high-tech solutions impractical.

To bridge this gap, a cost-effective, portable, and user-friendly communication aid is essential. The Smart Glove aims to convert hand gestures into speech, providing a real-time, affordable, and practical solution for individuals with speech impairments and paralysis. By leveraging low-cost sensors, Arduino-based technology, and wireless communication, this project ensures that assistive technology is accessible to a larger population and can be deployed in homes, schools, and healthcare facilities.

II. LITERATURE SURVEY

2.1 Kshitij Kadam, Sakshi Telange, Krishna Yadav, Ashish Vishwakarma, "Helping Hand : A Glove for Mute People", Published in 2023 at International Journal for Research Trends and Innovation (IJRTI) | Volume 8, Issue 4 | ISSN: 2456-3315.

In today's world the number of deaf and dumb people is very large, so the problems that are faced by those people can't be neglected. The major problem for those disabled people is communication and that too with normal people who can speak. A smart glove for mute people is a revolutionary device that has been designed to help individuals who cannot communicate verbally. This device uses advanced technology to enable people to communicate effectively by converting sign language into spoken language. The smart glove is a wearable device that is equipped with sensors and software that can recognize hand gestures and movements. The sensors detect the movements made by the user's fingers, and the software translates those movements into words or phrases. The disabled peoples use a particular language called as sign language which is not understandable by normal people. So in order to eliminate this problem there is a need to develop a product that can convert sign language to voice and text output which will make communication for disabled people with normal people easier.

2.2 Khushbu Pal, Pradnya Padmukh, Nidhi Patel, "Sign to Speech Smart Glove", Published at International Research Journal of Engineering and Technology (IRJET) Volume: 07 Issue: 02 | Feb 2020.

Every Normal human being sees, listens and then reacts to the situations by speaking himself out. But there are some human beings those who are not able to speak or listen, but they try to react through actions most of time normal people are not able to understand what they want to say. This application will help for both of them to communicate with each other. It consists of several parts, in part one with the help of hand gestures the signs will be detected by the sensors and the output will be given. Dumb people need to communicate with normal people for their daily routine or to express their emotions. The deaf-mute people throughout the world use sign language to communicate with other people. However, people who undergone from sign language training only they can communicate with another peoples. Sign language uses hand gestures and other means of non-verbal behaviors to convey their intended meaning It involves combining hand shapes, orientation and hand movements, arms or body movement, and facial expressions simultaneously, to fluidly express speaker's thoughts. The idea is to create a sign language to speech conversion system, using which the information gestured by a deaf-mute person can be effectively conveyed to a normal person. The main aim of this work is to design and implement a system to translate finger spelling (sign) to speech, using recognition and synthesis techniques.

2.3 Khan Sohelrana, Syed Faiyaz Ahmed, Shaik Sameer, Ollepu Ashok, "A Review on Smart Gloves to Convert Sign to Speech for Mute Community" Published in 2020 at 8th International Conference on Reliability, Infocom Technologies and Optimization (Trends and Future Directions) (ICRITO) DOI: 10.1109/ICRITO48877.2020.9197947

The mute community all over the globe facing many problems while communicating. The normal and dumb people can communicate only in one way i.e. sign language, but many times communicating with normal persons they noticed difficulty. Therefore, there always exists communication barrier. This communication barrier is seen because a speech impaired person uses gesture to commune with common human being which is not suitable. We are implementing this project to reduce the barrier between dumb and normal person. This device design is based on the embedded system. Flex sensor and NodeMCU are the key components. The peoples who cannot able to speak they come across many problems while communicating with other persons. The speech impaired person uses sign language instead of speaking to represent themselves. Deaf persons can communicate only by using gestures. The significant drawback of sign language is that only the dumb person can understand gesture but not normal person. This gadget transforms gesture into speech i.e., gives voice to silent community who cannot speak.

III. SCOPE

We went through all the projects and found the main problem of cost as all the project consisted of similar flex sensor which are at a high cost and are not at all applicable if we want to create help for society we have to eliminate the use of flex sensor which we did by introducing our own combinational circuit which is combination of resistors and metal contact plates which will be connected and disconnected according to the movement of the figures and will send signal to Arduino for further processing.

IV. PROBLEM STATEMENT

Paralyzed individuals face significant challenges in communication and independent interaction due to speech and mobility impairments. Existing assistive technologies are often expensive or lack a comprehensive solution for both communication and home automation. This project aims to develop a cost-effective smart glove that translates hand gestures into speech, enables appliance control, and integrates with a mobile application for messaging. By combining these functionalities in a single, user-friendly device, the project enhances independence, improves quality of life, and promotes accessibility for individuals with disabilities.

User: The person with disabilities will be the user to translate their actions.

V. APPLICATION

This system works using technologies. This application gives inputs from the user and processes it to find out the proper meaning. Then it gives responses in various formats through speaker and Mobile Application.

Assistive Technology – Helps paralyzed individuals communicate and control devices using hand gestures.

Healthcare – Can be integrated into rehabilitation programs for mobility-impaired patients.

Human-Computer Interaction – Enables gesture-based control for smart devices and IoT applications.

Robotics & Automation – Can be used to control robotic arms or prosthetics.

VI. PROPOSED SYSTEM

- Gesture vocalizer is a project that can convert sign language to human voice. The main idea of creating this project is to convert sign language of dump and deaf people to understandable human voice available for everyone. Our society is so diversified and we have a community of dump and deaf people who want to communicate with us, want to convey their thoughts towards us but are unable to do so. Hence we came up with an idea of creating a sign to voice converter without using flex sensor.

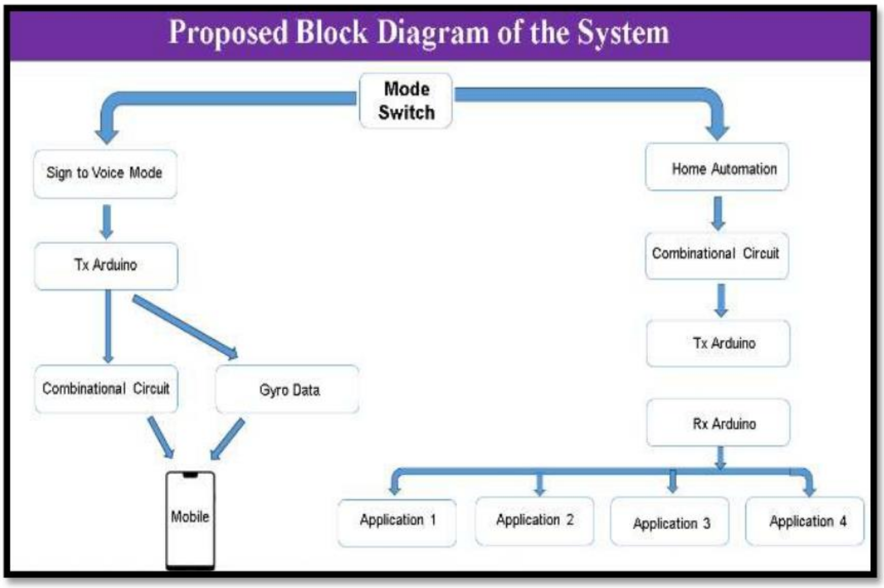

Fig 1: Block Diagram

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- As the flex sensor cost 1000rs for 1 piece and using 5 can cost a lot and the whole project will definitely go very high and our main aim is to reduce the cost so that we can make things available for the society and encourage our dump and deaf community with us .
- This project will convert their sign language to human voice by using a combinational circuit of open and close contact and along with it. It will also have accelerometer sensor to measure the deflection in the motion of their hand. This data will further be processed by Arduino and via using Bluetooth module it will be available on our mobile devices and we will get the data as sound form.

This project also has a home automation section which can be utilized using same gloves. This mode can be activated using a slider switch. We have connected 2 relay modules for ac devices and 2 dc source for motor and led interfaced to it.

Fig 2: Propsed System

VII. COMPONENTS USED

1. Arduino Uno

Arduino Uno is a microcontroller board based on the ATmega328P (datasheet). It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz quartz crystal, a USB connection, a power jack, an ICSP header and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with an AC-to-DC adapter or battery to get started. You can tinker with your UNO without worrying too much about doing something wrong. The worst case scenario is that you would have to replace the chip and start again.

Fig 3: Arduino Uno

2. NRF24L01 Module

The NRF24L01 module is very popular choice for wireless communication when using Arduino. The nRF24L01 is a single chip 2.4GHz transceiver with an embedded baseband protocol engine (Enhanced ShockBurst™), designed for ultra low power wireless applications. The nRF24L01 is designed for operation in the world wide ISM frequency band at 2.400 - 2.4835GHz. An MCU (microcontroller) and very few external passive components are needed to design a radio system with the nRF24L01.

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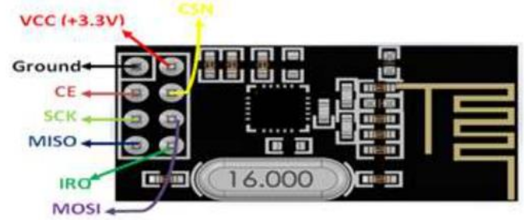

Fig 4: NRF24L01 Module

3. HC- 05 Bluetooth module

HC-05 module is an easy to use Bluetooth SPP(Serial Port Protocol) module, designed for transparent wireless serial connection setup. The HC-05 Bluetooth Module can be used in a Master or Slave configuration, making it a great solution for wireless communication. This serial port bluetooth module is fully qualified Bluetooth V2.0+EDR(Enhanced Data Rate)3Mbps Modulation with complete 2.4 GHz radio transceiver and baseband. It uses CSR Bluecore 04-External single chip Bluetooth system with CMOS technology and with AFH(Adaptive Frequency Hopping Feature).

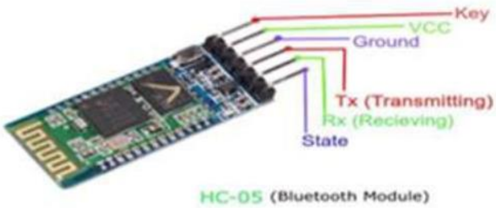

Fig 5: HC-05 Bluetooth Module

4. 5V Single-Channel Relay Module

Relay is an electromechanical device that uses an electric current to open or close the contacts of a switch. The single-channel relay module is much more than just a plain relay, it comprises of components that make switching and connection easier and act as indicators to show if the module is powered and if the relay is active or not.

Fig 6: Relay Module

5. ADXL 345 Accelerometer

The ADXL345 is a low-power, 3-axis MEMS accelerometer module with both I2C and SPI interfaces. The Adafruit Breakout boards for these modules feature on-board 3.3v voltage regulation and level shifting which makes them simple to interface with 5v microcontrollers such as the arduino.

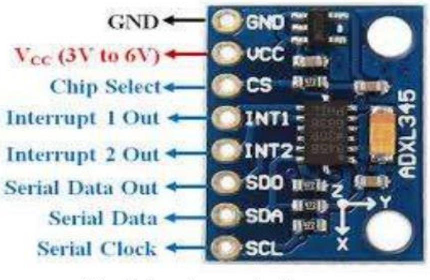

Fig 7: Accelerometer Sensor

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6. Combinational Circuit

Fig 8: Resistors

Fig 9: Metal Slab

This are the components used in combinational along with connecting wire which will send 1 and 0 signal to aurdino and this will be used to create the function of Flex sensor. The working of combinational circuit is as following:-

- There are two pieces of metal used which are placed on the glove which are placed above joints of one figure and two connecting wire are taken out which goes via resistor to aurdino .
- When one of our figure is curled or straight accordingly metal plates are connected or de connected .
- Case1 :- When fingers are straight the metal plates are connected and aurdino is receving 1 and one code is getting excecuted according to sign language chart.
- Case2 :- when fingers are curled the metal plates are Disconnected and aurdino is receving 0 and is will be counted as 0 and accordingly code is transmitted and depending on sign lang chart data is transmitted to 16*2 lcd and by using HC05 module data is futher transmitted to mobile device.

VIII. WORKING

- Case1:- If there is a condition when first four fingers are curled and thumb is raised straight then Arduino gets the input signal as (00001) along with the deflection in the Gyro sensor if any movement is observed and according to both signal input is fed to Arduino.
- The input signal to Arduino is calibrated with the series of data streams that are fed during programming we can feed as many as signals, every signal will be corresponding to movement of fingers position and gyro position, introduction of gyro has increased the amount of data that can be processed and can be detected on the \application that we have created and converted as voice form.
- Case 2:- When we move the slider in either direction then home automation is activated and now nrf to nrf communication takes place. Where in when we bend one finger the corresponding appliance i.e (relay1, relay2, dc motor, led) turns on and off according to signals it has received.

IX. CONCLUSION

This project successfully addresses the communication and mobility challenges faced by paralyzed individuals through a smart glove that translates hand gestures into speech and controls home appliances. By offering an affordable and accessible alternative to expensive assistive devices, it promotes greater independence and inclusion. The integration of wireless communication and mobile support enhances usability, making it a practical solution for daily life.

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1.1 Paper Publication Certificates

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*This is to certify that author "**Mr. O.G. Hastak**" with paper ID "**IRJMETS70300220534**" has published a paper entitled "SMART GOLVE TO CONVERT GESTURES TO SPEECH AND HOME AUTOMATION" **in International Research Journal Of Modernization In Engineering Technology And Science (IRJMETS), Volume 07, Issue 03, March 2025***

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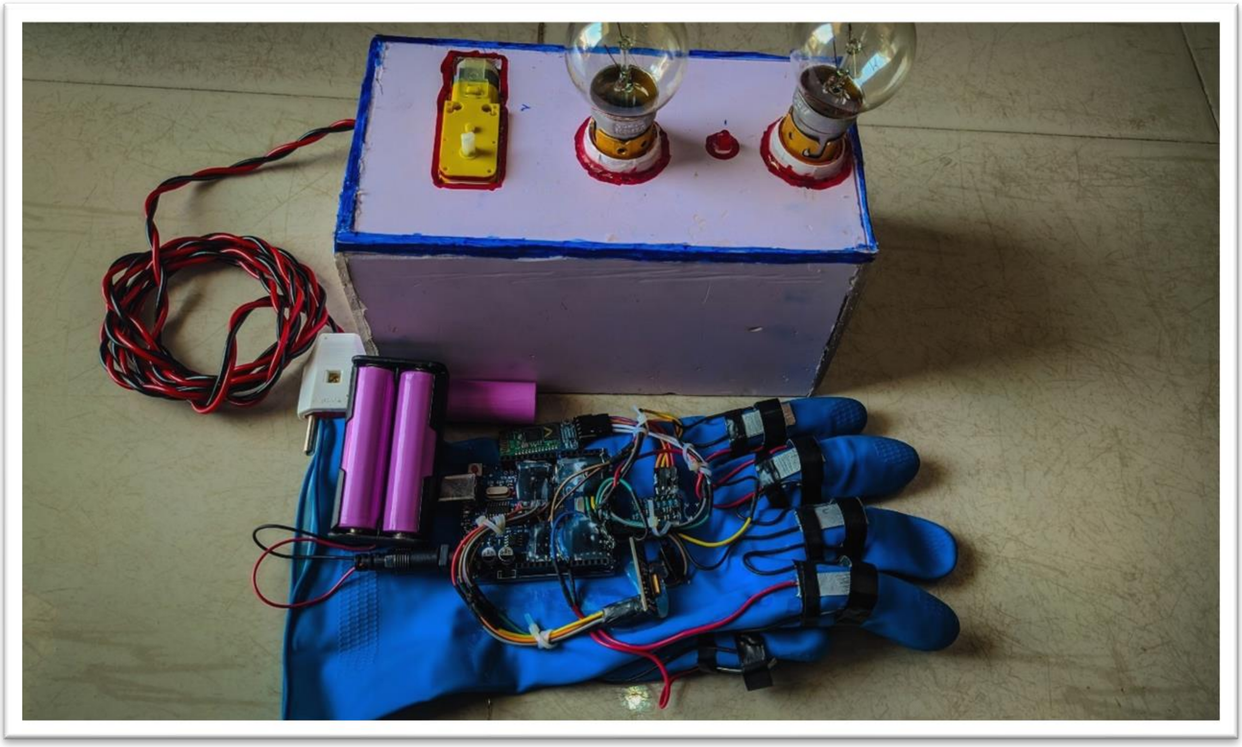
2.Project Team at a Glance

2.1 Project Module



3.Project Module:-

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1		Mr. O.G. Hastak	9423687618	ohastak@gmail.com
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4		Ved Botkewar	8080712706	vedbotkewar@gmail.com
5		Yash Ambildhuke	9665689415	yashambildhuke2020@gmail.com

4.Mapping of Project Outcomes with Program Outcomes

1. Demonstrate a sound technical knowledge of their selected project topic.
2. Undertake problem identification, formulation and solution.

OR

2. Be able to identify and summarize an appropriate list of literature reviews, analyze previous researchers' work and relate them to current project.
3. Design engineering solutions to complex problems utilizing a systems approach.
4. Communicate with engineers and the community at large in written oral form. (Real life, Industry based project)
5. Demonstrate the knowledge, skills and attitudes of a professional engineer through the implemented product.

OR

5. Be able to present the project outlining the approach and expected results using good oral presentation skills.
6. Able to work in team and communicate with peers.
7. Develop skills required by the industry.
8. Show correct attitude towards achieving the goals and objectives.
9. Be able to produce project outcome of good quality.
10. Be able to compile, analyze and present the output of project in the form of report.

6. Mapping of Project Outcome with Program Outcome

PO1	Demonstrate a sound technical knowledge of their selected project topic.
PO2	Undertake problem identification, formulation and solution.
PO3	Be able to present the project outlining the approach and expected results using good oral presentation skills.
PO4	Able to work in team and communicate with peers.
PO5	Be able to compile, analyse and present the output of project in the form of report.

Subject	**Project Outcomes**		**Program Outcomes**												**Program Specific Outcome**	
			1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**1**	**2**
Final Year Project	PO1	Demonstrate a sound technical knowledge of their selected project topic.	1	3	3	2		2	3	2	3	3	1	3	2	
	PO2	Undertake problem identification, formulation and solution.	3	3	1	3		1	2		2	2	3	3	3	3
	PO3	Be able to present the project outlining the approach and expected results using good oral presentation skills.	3			3	2	2		1		3	3	3	2	
	PO4	Able to work in team and communicate with peers.			2			2			3	3		3	2	
	PO5	Be able to compile, analyze, and present the output of project in the form of report.	3	3	2	3			2	2		3	2	3		2

6. Project Poster

THANK YOU