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Multi-Purpose Smart Glove for Differently Abled Community People

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A B S T R A C T

The Smart Glove is designed primarily for interaction between disabled and non-disabled people. In this context, disabled refers to deaf and hard-of-hearing people who use sign language to communicate with one another and with others. However, because the majority of people are not familiar with sign language, communication between the deaf and hard-of-hearing and the general public can be difficult. A mediator is required to explain the rights of deaf and hard-of-hearing people to the general public, a person's sign language. As a result, the primary goal of this project is to provide a portable and smart solution to meet the demand for converting disabled people's gestures into a text and speech synthesis format that others can understand. This Smart Glove can also control home appliances and monitor your health. The user will have an application installed that will assist them in switching between various modes of operation of our Smart gloves. These smart gloves make life easier and more independent for people with special needs.

Keywords:Smart Glove, Sign Language, Home Automation, Health Monitoring , Flex Sensor.

1. Introduction

Many deaf and hard-of-hearing people communicate primarily through sign languages. Sign languages are typically used by the deaf, but they are also used by those who can hear but cannot speak. Hands and hand shapes In sign language, movements are used to express thoughts. They also use a combination of words and symbols to communicate. The primary goal of this project is to break down communication barriers between people with special needs and the general public. Our system will allow the user to express themselves verbally by using glove gestures and finger bending with a flex sensor.

This data is in analogue form, which is then converted to a digital signal using the Arduino nano and sent via Bluetooth to a smartphone for display of words on screen. For the home automation aspect, these converted digital signals are also sent to the RF module. The health of mute people is another issue. To address this, our system will include a heart sensor that continuously monitors the user's data and displays the results on the user's smartphone. A vision-based gesture recognition system, which uses a camera module to capture hand gestures, is one existing method of expressing thoughts. The captured image is sent to image processing, which generates an output based on the captured image. Sensor-based gesture recognition is more accurate and takes less time than vision-based gesture recognition. It also reacts quickly when recognising gestures. Sensor-based systems require flex sensors rather than camera modules, making them portable and low-cost.

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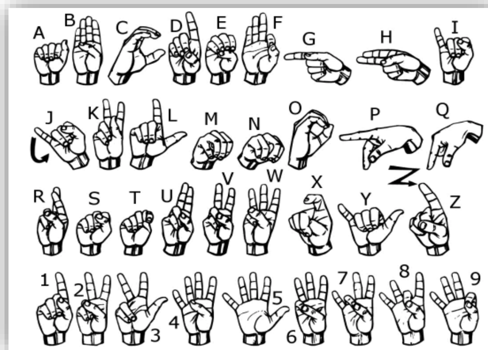

Fig 1 – American Sign Language Chart

2. Literature Review

In the topic of smart communication for visually and hearing-impaired people, a number of studies and research have been undertaken. According to this, sign language, in addition to writing and sketching, is the most effective medium for fluent communication between ordinary people and these specially challenged persons. In this field, numerous patents have been filed with various techniques to address this problem.

I. Dalal-Abdullah took a different method in his creation of a sign-to-speech or text system for deaf and dumb persons. In which he proposed the creation of an electric gadget that consists of two parts, one of which serves as a transmitter and the other as a receiver. The goal of this technology was to transform Arabic sign language into speech or text. The concept was simple: each finger would have flex sensors attached to an Arduino. The data from flex is collected by this microcontroller and delivered via the RF transmitter. The RF receiver, on the other hand, receives the transmitter's output and delivers it to the Arduino Mega, which then processes it creates the LCD's and speakers' output. They utilised the Arduino IDE to map the data to the gestures made. The Arduino IDE has space an d speed limits, which is a disadvantage. Their method only allows for a small amount of gestures. Another constraint is the usage of flex se nsors, as the resistance value changes when the system is used more intensively. As a result, the chances of acquiring the correct output are reduced by a certain proportion(American University of Ras Al Khaimah & Institute of Electrical and Electronics Engineers, n.d.).

II. Another approach was made by Abhinandan Das in his paper, using flex sensors and gyro sensors for finger and hand movement respectively. He used a flex sensor on each finger and a gyro sensor to detect hand movement in this. This increased the combinations of gestures, thereby increasing the dataset of gestures. The transmission of data is done through Xbee transceivers for effortless data flow. They used the Intel Galileo Gen 2 loT kit to analyse and classify the actions and hand movements in the sign. The need to use this powerful processor was to easily classify the gesture types. As per the system developed by them, the gestures made by a user can be an alphabet or a number for which proper classification is needed. Using this powerful intel processor, the data is processed easily. Once the data is received, it is processed by a microprocessor, and the output is shown according to the text mapping to the sign language. The text generated is displayed on the Grove-LCD. Further, it is converted to speech via the Grove-buzzer sensor. The major drawback to this whole setup is that it can generate around 200 words only. Another downside to this system is the use of alphabets and numbers, which radically slows down communication(Assam Engineering College et al., n.d.)
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III. Arslan presented a framework for interpreting sign language using gloves. Five flex sensors, a microcontroller that processes sensor readings, an LCD that shows individual results, and a speaker that listens to the output make up the framework. It produced a visual display on an LCD as well as an audio output through the speaker. The disadvantage of this method is that it restricts the user's freedom of movement(Nazir et al., n.d.)

IV. The work that is being proposed Hand gestures are a powerful means of communication for those who are deaf or hard of hearing. Deaf, blind, and stupid people communicate via sign language, which is difficult to understand for others who aren't familiar with it. As a result, a gadget that can translategestures into text and speech is required. The primary purpose of this project is to develop a smart glove system that can recognise indications in real time. Gestures in a language must be converted into spoken words. "Artificial speaking mouth for dumb people" is a new method. A flex-sensor and a magnetometer are built into the glove to detect finger movement. The system translates the signs recognised into meaningful text. This text is then transferred to a smartphone app over a Bluetooth channel where the text will be converted into speech. Another feature that makes this project interesting is that users can teach the system new gestures and add them to the existing standard gesture library(Hemavani, 2017)

V. Ambika Gujrati et al. proposed a system that consisted of flex sensors, tactile sensors, and accelerometers. Their hardware requires Hence, a voltage regulator from the 7800 series (7805) is used. LEDs are used to provide information about the supply is activated. A 330Ω resistor is used to drop the voltage and make it 2-2.5V as required by the LED. The deflection of the flex with a minimum angle of 40° produces a resistance which is increased by bending and voltage is obtained. Four flex sensors along with their connection ports are placed. The voltage is in, so an op-amp (LM358) was used to amplify it. The op-amp used is a non-inverting type with high gain in voltage. The Rf resistor is a variable resistor with a range of (0–10) k and a resistance of 2.2k. A 33k resistor is used at the output of the op-amp which stops the voltage from being grounded. PIC16F877, a peripheral interface controller, is used with flash memory of 8 kb and an inbuilt ADC converter with 10 bit resolution. The microcontroller converts the analogue output into digital and provides a high and low voltage. A crystal oscillator at 12MHz is used, which provides the microcontroller with a high-frequency clock pulse. Two 33pF capacitors are used along with the oscillator. The high or low voltage is then passed to an NPN transistor which gives the output which is further sent for retransmission. Relays used to have an internal magnetic field. They act as an ON-OFF switch. One relay acts as a play button. Then the third flex sensor will act. The forward relay will be forwarded 2 times and then played, and similarly, others will operate. The message is now forwarded to the voice recorder ISD1720, which has a microphone and speaker connected to it. Electrolytic and ceramic capacitors are used, which remove the ripples and cancel out the noise. An RF circuit is used which provides automatic gain control which gives constant output. The voice can be recorded through a microphone and, according to the flex deflected, the output is received from the loudspeaker. Their circuit diagram shows the capability to measure or translate 7 potential sign language words(Manoharan S., Ragul R., Ramanathan S. K. S., Vijay M., 2021)

VI. A smart glove is a communication technology that combines augmented and alternative communication methods. AAC (additional and alternative communication) is a key component in the creation of support services for people with disabilities, particularly those with severe disabilities. Augmentative and alternative communication (AAC) technologies, for example, can help to reduce this separation from others. An AAC system is a collection of components that includes symbols, aids, tactics, and procedures that people use to improve their communication. These technologies span from relatively low-tech systems to quite high-tech ones (i.e., simple adaptations with no batteries or electronics, such as communication boards). Unaided communication systems and aided communication systems are the two broad categories in which AAC systems fall. For the production of expressive communications, unaided AAC systems do not require any kind of external communication equipment. Unaided ways of communication include sign language, facial expressions, gestures, and non-symbolic vocalizations. The construction of aided systems necessitates the use of an external communication device.(*KhushbooKashyap-Digital Text and Speech Synthesizer Using Smart Glove*, n.d.)

3. Methodology

Recognizing sensor values, processing, and displaying/listening according to the sign are the three basic processes of American Sign Language translation. The flex sensor, which is just a variable resistor, is the most important aspect of this project. These sensors are constructed of carbon on plastic strips, and the resistance of the flex sensor changes when the strip bends or deflects. For the thumb, we used one flex sensor and four sensors for the remaining fingers of the hand. The flex sensor utilised in this project is 2.2 inches long, which ensures accuracy and precision in results. As the component's body bends, the flex sensor's resistance increases. The values of the flex sensors and accelerometer are the major input to the Arduino Nano, as seen in the block diagram below. The results from the flex sensors and accelerometer are received when the hand is in a specified position according to the sign language. The microprocessor converts the change in resistance into voltage, which it then processes. A sign's specific value falls inside the range indicated for that sign, assisting in the detection of alphabets and words. The alphabet is wirelessly transferred after a match is identified, and the alphabet/word is shown and heard on the Android application. Home automation and health monitoring will work on the same principle, in that when the user makes a gesture, the system will respond ie When the user makes a gesture, it is processed and transmitted from the transmitter to the receiver, and the appliance attached to the relay is switched on or off. Similarly, the pulse sensor will measure the user's pulses and send them to the application via the HC-05 module.

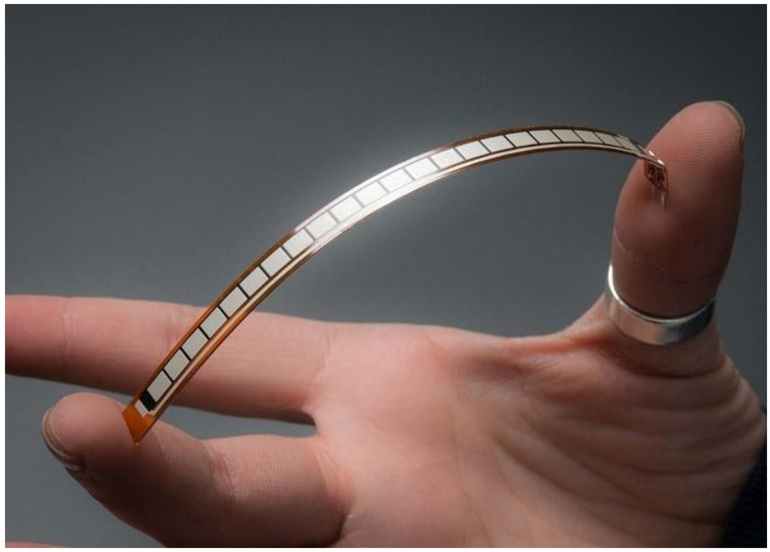


Fig 2- Flex Sensor

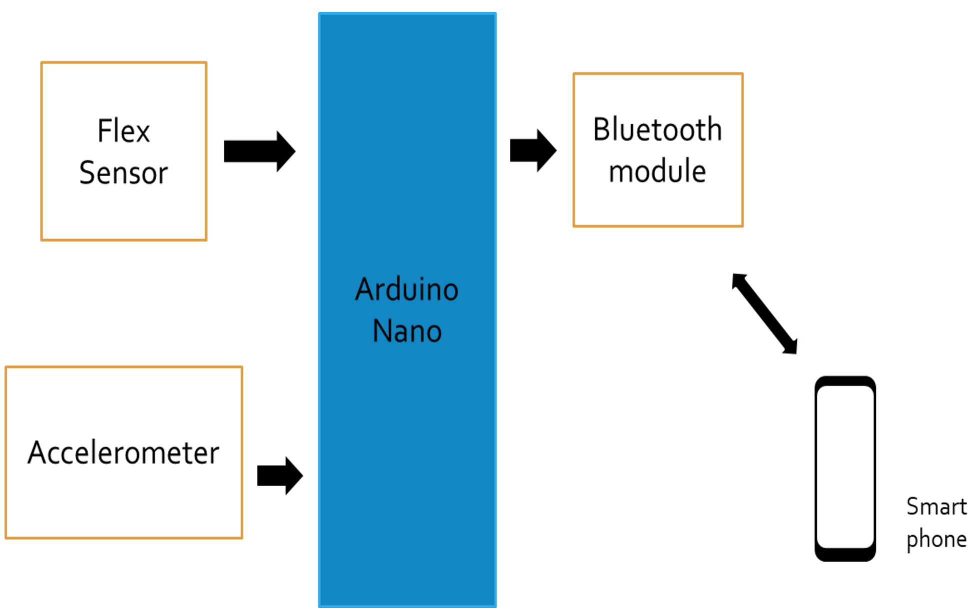


Fig 3- Block Diagram

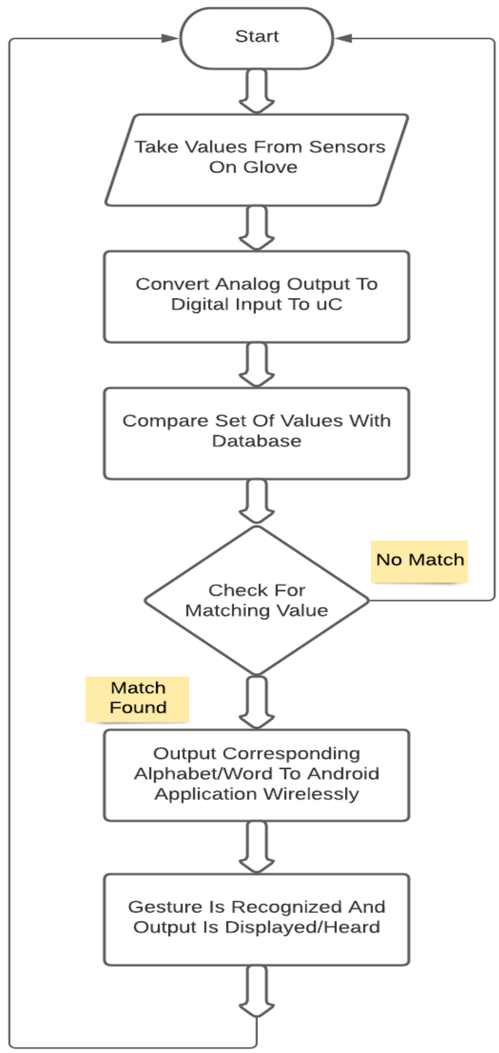


Figure 4 shows a flowchart that shows how the algorithm works. To begin, a voltage divider is used to transform the resistance values of flex sensors into voltage. The accelerometer readings are already formatted correctly. Flex sensors are positioned on each finger in such a way that each finger has one. When bending on the joints, the flex sensors display a change in resistance, which is then processed to filter out superfluous oscillations and send only useful data into the microcontroller, and the values of both sensors are then compared to the specified data set crafted after multiple scenario experiments. All of the sensor values, including those from the accelerometer, as well as those from the Arduino Nano and our system, will now be compared, and once the signs have been identified and a match has been found, the sign will be wirelessly transferred to the android device via Bluetooth module to the custom designed mobile android application named "Translator," which will then show the sign.Now, all of the sensor values, including those from the accelerometer, as well as those from the Arduino Nano and our system, will be compared, and once the signs have been identified and a match has been found, the sign will be wirelessly transferred to the android device via Bluetooth module to the custom designed mobile android application named "Translator," which will then display the alphabet or word and can also be toggled for speech output. This user-friendly mobile application adds originality to the scope of the project due to its audio/visual output, mobility, and cost-effectiveness.

4. System Components

Main components for this project include a hand glove, flex sensors,accelerometerandgyroscope(MPU6050),9Vbattery, Bluetooth module (HC-05), 1kΩ resistors, contact wires, Arduino Nano, Arduino Micro, NRF24L01+ transceivers, Pulse sensor and an Androidapplication.

I. Flex Sensor

Each finger was fitted with a total of five flex sensors. Flex sensors are piezoresistive sensors whose resistance changes with the bend and thedirection of the bent. Each joint has a flex sensor implanted on it to detect bend, as every symptom is a variation on the joints. Flex sensors in combination with a voltage divider design produce the best results, suppressing fluctuating values into tolerable ranges while yet allowing for abrupt fluctuations to be handled by a bespoke filter. The ADC receives the output of this The voltage divider design uses a 5 volts input to ensure cohesiveness between the sensors and the ADC, as the ADCcan handle a 5 volts input. To get the best results for flex sensors, utilise 1k as the constant resistance in the voltage divider design since it delivers a reasonable voltage range with the flat and bent resistance of the flex sensor from equation (1) as shown below.

***VADC* = [*Rflex* / (*Rflex*+ *Rin*)]∗*Vin*--------------------- (1)**

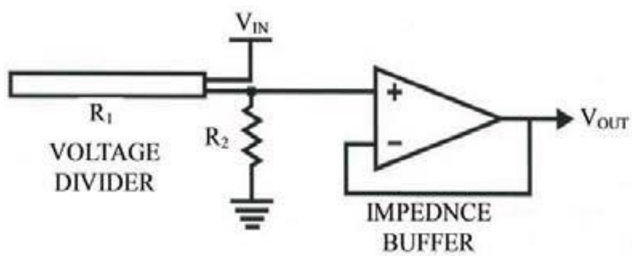


Fig 5 – Flex Sensor Circuit

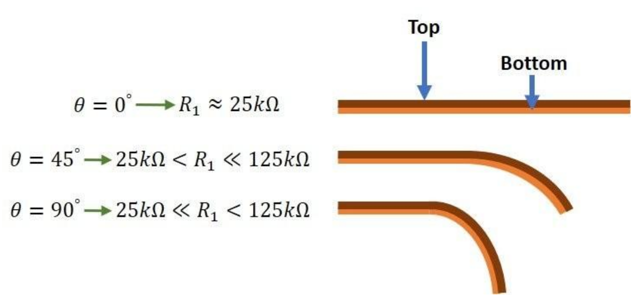


Fig 6 – Bending of Flex Sensor

II. Microcontroller

The Arduino Nano (transmitter side) and Arduino Pro mini (receiver side) was chosen to maximise resource consumption. Both have MISO, MOSI, SCK pins for NRF24L01+ modules. Nano came with the necessary number of analogue and digital pins. It contains SDA and SCL pins for MPU-6050, as well as TXandRXpinsforHC-05Bluetoothmodule.Theflexsensors' output is transmitted to the Arduino Nano's analogue pins, where a 10 bit ADC maps out the sensor readings between 0 and 1023 bits, indicating 0 and 5 volts. If the input voltage is 5 volts, the output is 1023, and if the input voltage is 2.5 volts, the output is 512. The sign programme is made up of ranges within these distinct ranges. In order to detect a specific sign, these digital values would be employed in a programme. The ADC has a 5 millisecond step size. All of the values were calculated by the following equations (2) and(3).

Stepsize = [Vmax / 2bits] = [5/2^10] ----------------------------------- ---------(2)

Dout = [VADC/Stepsize] ------------------------------------ (3)

Fig 7 – Arduino Nano

Fig 8 – Arduino Pro Mini

III. Accelerometer + Gyroscope (MPU-6050)

The MPU-6050 is used to recognise signs that need a specific hand position or finger orientation, such as I, J, Z, HELLO, HOW ARE YOU, NICE, MY NAME, and HELP. For precision,thevaluesofsensorsfromfingersandtheMPU-6050 were fixed at a precise angle in order to detect the special indicators that involved movement. In the case of words, the MPU-6050 makes dynamic sign identification intuitive and accurate for theuser.

Fig 9 – MPU 6050

IV. Bluetooth Module (HC 05)

This HC-05 Bluetooth module makes it simple to send and receivedatawirelessly.TheHC-05isaplug-and-playlow-cost, low-resource bluetooth module that operates at 3.3 volts and can transfer data over distances of up to 20 metres. Its modest profileisidealforaddressingourportabilityrequirements.The signaltransmittimeofvariousdevicesismaintainedata0.5 second interval in this module, reducing the stress on the bluetooth chip and allowing additional sleeping time to be set aside for bluetooth. This module is simple to use and streamlines the entire design/development process.

Fig 10 – HC05

V. NRF24L01 + module

The nRF24L01 is a wireless transceiver module, which means it can send and receive data wirelessly. They operate at a frequency of 2.4GHz, which is part of the ISM band. We are using two nRF modules for our Mode 2 which is Home automation i.e. one for transmitter side and one for receiver side.Whenusedproperly,themodulesmaycoveradistanceof up to 100 metres (200 feet), making them an excellent solution for all wireless remote controlled applications. Because the module operates at 3.3V, it can be utilised with either 3.2V or 5V systems. Each module has a 125-bit address range andmay connectwithuptosixothermodules,allowingseveralwireless units in a given region to communicate with one another. As a result,thismodulecanbeusedtocreatemeshnetworksorother sorts ofnetworks.

Fig 11 – NRF24L01+

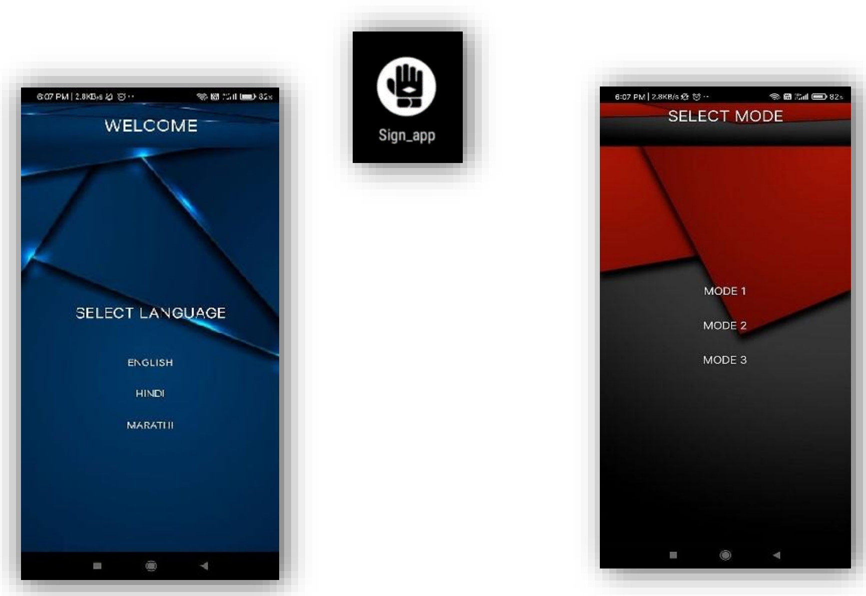
VI. Pulse Sensor

This Biometric Pulse Rate or Heart Rate Detecting Sensor is a Plug and Play type sensor module that we are employing for ourMode3whichisHealthMonitoring.Ithasa+5Vor+3.3V operational voltage and a 4mA current consumption capacity. Itfeaturesanoisecancellationandamplificationcircuitbuiltin. The sensor has two sides, on one side the LED is placed along withanambientlightsensorandontheothersidewehavesome circuitry. This circuitry is responsible for the amplificationand noise cancellation work. The LED on the front side of the sensorisplacedoveraveininourhumanbody.Thiscaneither be your Finger tip or you ear tips, but it should be placed directly on top of avein. The veins will have blood flowinside themonlywhentheheartispumping,soifwemonitortheflow of blood we can monitor the heart beats as well. If the flow of blood is detected then the ambient light sensor will pick up more light since they will be reflected by the blood, this minor change in received light is analysed over time to determine our heart beats.

Fig 12- Pulse Sensor

VII. Android Application

The application is the glove's response. It not only displays the currentletterorword,butalsospeaksitout.TheAndroidapp's text-to-speech capability makes the software more responsive. This feature improves the user experience by playing back the received text through the mobile device's speaker at the same time. The multi-featured programme"Translator" includes a sign chart for visual sign interpretation. It supports several languages and offers a simple interface for switching between different modes of work, increasing user engagement and experience. The application's design is kept basic. It is a user- friendly and resource-constrained Androidapplication. The Massachusetts Institute of Technology now supports App InventorforAndroid[10],anopen-sourcewebapplicationfirst released by Google and now sponsored by the Massachusetts Institute of Technology (MIT). We used the block coding featuretocreate"Translator"onit.Figure10depictsaworking prototypeofthesystem,completewithmodulesandanAndroid application. This comprehensive bundle bridges the communication gap between deaf/mute and normalpeople.



5. Expected Result

When mode 1 is selected, the flex sensor and accelerometer angles values are used to show words or sentences encoded in precise movements on the screen. On mode 2, the home automation section will be accessed, and the gestures we introduced to a specific output will be transmitted and received through the nrf24l01+ module (Transceivers), and that received output will be fed to Arduino, who will then pass the signal to the 4 channel relay module, and outputs, such as turning on/off the fan or turning on/off the light, will be executed. When mode 3 is selected, health monitoring will take readings from an Arduino Nano connected pulse sensor and transfer the data to the app over Bluetooth, where the user's heart pulse values will. When mode 1 is selected, the information from the flex sensor and accelerometer are used to display words or messages encoded in exact movements on the screen. The home automation section will be accessed on mode 2, and the gestures we introduced to a specific output will be transmitted and received through the nrf24l01+ module (Transceivers), and that received output will be fed to Arduino, who will then pass the signal to the 4 channel relay module, and outputs, such as turning on/off the fan or turning on/off the light, will be executed. When mode 3 is selected, health monitoring will collect data from an Arduino Nano attached pulse sensor and send it over Bluetooth to the app, where the user's heart pulse values will be displayed.

6. Conclusion

By combining flex sensors on the glove with other hardware components in a portable design centred on the user, this study employs a smart glove to translate American Sign Language. The user makes an ASL sign, which is then translated by Arduino Nano. Following processing, the data is transferred to an Android app for visual and auditory presentation. The project's major purpose is to recognise ASL-based sign signals and turn them into useful data so that deaf and hard-of-hearing people, as well as the general public, can communicate more effectively. This project could be upgraded in the future to include internet capabilities, allowing for more uses.

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