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Smart Glove: Designing Of Hand Motion Translator For Deaf And Dumb Person

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ABSTRACT

Hand gestures, a vital non-verbal mode of communication, rely on the bending of fingers to convey messages. To reduce barriers and enhance confidence among individuals who use such gestures, several technologies have emerged to bridge the gap between those with and without disabilities. Our project aims to develop a cost-effective electronic hand for gesture recognition, utilizing flex sensors and an ESP32 microcontroller. Flex sensors operate by detecting changes in internal resistance, thereby capturing the angle formed by the user's fingers. By combining various finger movements, unique gestures are formed, which can then be interpreted into signals and presented as text on a screen or conveyed audibly through a speaker. This system facilitates the recognition of human sign language, empowering machines to perform tasks or identify words based on hand gestures and respond accordingly.

Keywords: Smart Glove, Deaf And Dumb, Realtime And Portable, Gesture Recognition, ESP32, Sparkfun Flex Sensor, American Sign Language (ASL)

INTRODUCTION

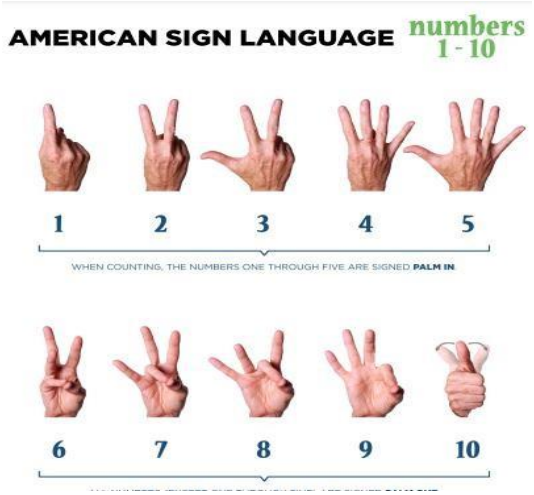
Human relationships are strongly reliant on communication, particularly speech, which serves as an important medium for conveying thoughts, ideas, and opinions. Speech creates peaceful situations in which people may share, learn, and grow together. It is a means by which civilizations communicate beliefs, stories, and wisdom, improving human interactions. Individuals who are unable to communicate

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owing to disability may experience loneliness, frustration, and emotional discomfort. This failure to connect might result in isolation from the community and a lack of social support. Communication impediments worsen difficulties in school and employment, resulting in dependency and lower self-esteem[1].
Misunderstandings and confrontations occur, further impeding integration into society and promoting social stigmatization and prejudice.
Individuals with hearing and speaking difficulties were previously referred to as "deaf" and "dumb". Deafness, whether congenital or acquired, can be total or partial, with variable degrees of hearing capacity. The prevalence of hearing loss and speech impairment due to birth abnormalities, diseases, and accidents has increased, impacting more than 5% of the global population. Millions of young kids are at risk of hearing loss due to unsafe listening habits, with over 530 million requiring rehabilitation. By 2050, an alarming 700 million people are expected to have significant hearing loss[2][3]. The World Report on Hearing emphasizes the critical need for rehabilitation, as millions of people worldwide struggle with hearing problems, even with the use of hearing aids. Overall, one in every five people worldwide today suffers from some forms of hearing loss [4].
According to the World Health Organization, around 11 million Pakistanis, out of a population of
231.4 million in 2021, have hearing or speech difficulties. Furthermore, a 2010 National Institute of Deafness and Other Communication impairments survey found that almost 7.7% of children aged 3 to 17 in the United States have voice, speech, or language impairments [5]. These diseases range from selective mutism to ADHD and stuttering, all of which have an influence on people's quality of life. Sign language is an important form of communication for the deaf and dumb, involving both manual and non-manual gestures to transmit thoughts and concepts. However, the global diversity of sign languages, with over 300 active forms, makes it difficult to establish a universal communication standard. Nonetheless, advances in gesture recognition technology provide promising options for facilitating communication between hearing and
non-hearing people, increasing inclusivity and understanding in society. [6]
American Sign Language (ASL) as shown in Figure. 1, Figure. 2, is a different language from English that includes all important language components such as grammatical structure, sentence formation, and diction.



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Figure 1: Numbers (1-10) in ASL [7]

ASL's syntax and rules for communicating meaning via gestures and symbols are vast and well-developed. Hand movements, frequently supplemented by facial expressions, are the fundamental mode of communication in American Sign Language, often known as signs. This language, which is rich in variation and cultural nuances, is not based on speech or sound, distinguishing it from spoken languages. As with any language, ASL has its own grammar, syntax, idiomatic expressions, slang, and regional variations. It serves as a common language for the deaf community, promoting communication and instilling a sense of belonging in its users[8].

Technological advancements have resulted in the creation of novel ways to overcome communication barriers between those with hearing or speech impairments and those without. One such option is a smart glove that can translate sign language motions into text and speech, lowering communication barriers and increasing inclusivity. The glove recognizes hand gestures and translates them into comprehensible outputs, with a focus on American Sign Language (ASL). Flex sensors built in the glove detect finger and thumb movements, while a gyroscope measures rotation for perfect gesture detection.

The device, which focuses on ASL alphabets, numerals, and specific sentences, improves communication by giving real-time text and speech outputs. Portable and user-friendly, the smart glove provides smooth interactions, allowing users to express themselves with precision and fostering meaningful connections between ASL speakers and non-speakers. This revolutionary technology transforms communication for people with various needs, encouraging inclusivity and understanding in society.



Figure 2: Some Common gestures in Sign Language.

LITERATURE REVIEW

Sign language (SL) expressions require complicated hand and body gestures, which pose substantial hurdles despite the fact that many scholars have studied SL recognition and gesture identification. Studies on SL identification are divided into three categories: computer vision- based, data glove and motion sensor-based, and hybrid techniques. As sensor and computer technology advanced, ASL and other computer vision-based SL recognizers became more efficient [9]–[10].

K. N. Tarchanidis and J. N. Lygouras et.al; introduces a data glove with a force

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sensor. The glove uses flex sensors for finger position sensing and strain gauges for force measurement. The flex sensors are powered by DC voltage and the measured values are transmitted to a PC. The Glove is made of rubber-coated cotton and the sensors are securely attached using glue. Data gloves are extensively utilized for a variety of purposes, including as a communication aid for the deaf and speech-impaired people as well as an input device and platform for 3d visualization, robotics, and biomechanics. The main focus of this proposed system is on recognition based computer
vision. On the other hand, Numerous researches are also exploring the use of gloves and motion sensors for interpreting ASL and other SL. [11], [12], [13]. This study suggested creating a national sign- writing system with symbols for each unique hand pattern, position, and motion. One significant characteristic, palm orientation, was recommended following this research [9]. H. Wang, M. C. Leu, and C. Oz, et.al; uses a sensory Cyber glove, a Flock of Birds 3-D motion detector, and an artificial neural network approach to detect the motions., and they reported a 96.0% recognition accuracy for a 26-letter American Sign Language (ASL) alphabet [13]. This work is further continued by J. L. Hernandez-Rebollar, Presents a hidden Markov modeling approach with 8 sample training set with 95% detection accuracy for the 26 alphabets and 36 basic hand gestures in the ASL [14].

L. Dipietro, A. M. Sabatini, S. Member, and P. Dario, et.al; presented an Acceleglove, used for detect signs and it achieves a recognition accuracy of 99.3% for 22 signs without using a predictor, but with the use of predictor the detection accuracy for seven sentences reaches a perfect 100%. The delay time for each sign phrase is always one second [15].

Sidney Fels and Geoffrey Hinton et.al; proposed a glove system consists of a variety of sensors, electronics for qualitative research or computation, a battery charger, and a base for hand-worn sensors. Here, many types of gloves including LED, data, Sayre, and cyber are used. The user is assisted in choosing the right glove for the job by a glove-based system [16].

Giancarlo Orengo, Antonino Lagati, Giovanni SaggioFocusing et.al; proposed a model for fast signal recovering in human motion Analysis. This research paper focuses on the sign language to speech approach, the system Glove Talk II converts hand motions into audio by using neural networks.it creates a synthetic auditory canal and allows users to communicate with their hand by modifying the settings of a parallel format speech synthesizer. It's an adaptable interface that opens up new possibilities for sign language to speech communication [17].

S. K. M, et.al; designed a model using Indian sign language for gesture recognition. The model tracks the movement of human joints and restores the original waveforms, which show the tilting of the
joint and the fastest human speed. Using bend sensor modeling, it has been demonstrated that these sensors can detect changes in people's posture [18].

G. Rajadhyaksha, S. Mody, and S. Venkateswar et.al; Speech synthesis is the technique of producing synthetic human speech through the use of a hardware- or software-based device known as a speech synthesizer. Speech synthesis is frequently used in text-to-speech (TTS) systems, which translate written text into spoken words. This conversion is what our system attempts to do, concentrating on alphabet and

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numeric recognition from keyboard input from the user. Providing a spoken representation of the input text is the aim. In order to do this, the system synthesises the text using a speech processor, dividing it into smaller units known as allophones, and then produces the appropriate voice output [19].

M. I. Sadek, M. N. Mikhael, and H. A. Mansour et.al; designed a Smart Glove using arabic sign language. Text data is voiced over using a sound synthesizer called Speak Jet. It generates a voice signal by controlling a five-channel sound synthesizer using the mathematical Sound Architecture (MSA) approach. It has 12 DTMF touch tones, 43 audio effects, and 72 phonetic parts. The user can create a variety of sound effects by employing the MSA component as well as the pitch, rate, bend, and loudness parameters. A smart glove for Arabic sign language is based on 6 flex sensors out of which 4 are used via the arduino to detect the angles and produce their respective words, whereas the thumb and palm are accomodated through a device called " comparator LM239" [20].

Mr aleem khalid alvi et.al; proposed a model called "boltey hath" hand-worn device based on Pakistani Sign Language (PSL) which is a human-computer interface (HCI) programme. It chose a subset of PSL to implement, focusing on single-handed movements. This system is built using five finger sensors and one tilt sensor, all of which are saved in a gesture data bank throughout the data gathering phase. This system uses two distinct approaches: statistical template matching (STM) and artificial neural networks (ANN) [21].

The dynamic sign language part of the system operates in three stages: first, it gathers important information from the dataset, then it trains a long short-term memory (LSTM) model and uses open

CV linked with the Kinect device to make predictions in real-time based on sequences. Additionally, it enables hearing users to record Urdu audio directly into the Kinect microphone. The suggested sign language translator can translate text into Urdu and recognize and anticipate PSL done in front of the Kinect device. This work is further continued by K. Kanwal et.al; who designed a wearable glove contain ten different gestures, which translate motions in Urdu Sign language. This system was designed to use a pattern recognition approach. In this model Principal Component Analysis (PCA) was introduced for feature extraction and Euclidean distance as a classification technique in order to reach the targeted output [22].

METHODOLOGY

The development of a smart glove for individuals with hearing and speech impairments marks a significant step towards enhancing their communication capabilities and quality of life. The methodology includes phases that are iterative testing, software development, and hardware integration. The prototype starts with choosing and acquiring components, such as flex sensors, an ESP32 microcontroller, an MPU6050 accelerometer, and a PAM8403 audio amplifier, and an OLED display, the methodology proceeds to the assembly of the physical glove prototype.

HARDWARE DEVELOPNMENT:

The development of a smart glove for individuals with hearing and speech impairments marks a significant step towards enhancing their communication

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capabilities and quality of life. The methodology includes phases that are iterative testing, software development, and hardware integration. The prototype starts with choosing and acquiring components, such as flex sensors, an ESP32 microcontroller, an MPU6050 accelerometer, and a PAM8403 audio amplifier, and an OLED display, the methodology proceeds to the assembly of the physical glove prototype.

Initially, flex sensors and an MPU6050 accelerometer are selected because of their capacity to record hand orientations and finger movements. The purpose of these carefully positioned sensors on the glove is to precisely identify gestures. The MPU6050 accelerometer measures the hand's motion in three dimensions, while flex sensors are positioned along the fingers to monitor bending. The next step is to connect these sensors to the ESP32 microcontroller, which functions as the central processing unit. The ESP32's analogue input pins are connected to flex sensors, which enable the microcontroller to detect resistance variations that correlate to finger bending. Concurrently, the ESP32 and the MPU6050 accelerometer exchange data in real time on the orientation and motion of the hand.

SOFTWARE DEVELOPNMENT:

For software development Arduino IDE is used, to enable the ESP32 microcontroller. Arduino IDE which is an open-source platform that is used to sketch the whole code for the process of flexsensors input and identify gestures accurately. Algorithms are used to interpret sensor data and recognise particular motions, such waving, pointing, or tapping the finger. To receive and transmit the data from peripheral devices different libraries have been installed which were not built- in in the IDE.

The sketch initializes the libraries and pin numbers of the components communicating with the server. It loops through IF/ELSE commands for 20 movements based on specific conditions and ranges. Additionally, a push button is equipped and programmed for the mere purpose to ON/OFF the prototype. After sketching and wiring the algorithm is uploaded to the ESP32 via laptop connection and powered by microUSB. It detects specific movement ranges from flex sensors and display commands on the OLED. Raw values are read from the flex sensors, compared to the set ranges, and matched to trigger commands. An MP3 player is interfaced with the ESP32, allowing voice-based output to be played through a speaker. For instance, the subject makes a specific gesture, the signal generated because of potential difference will be acquired by the flex sensors attached to the glove. It is then fed to the ESP32 to interpret the analog data and match it with the given ranges. Once it is matched the text message assigned to the movement such that based on certain conditions with set of ranges for every movement will be displayed on the OLED and the displayed command will then be voiced out at the same time to complete the process.

However, if it doesn't find any match then the no display of indication will initiate until the next movement will be given or acquired as shown in the system flowchart and pictorial graph for the prototype is given in Figure.3 and Figure.4

Figure 4: Block Diagram of Smart Glove

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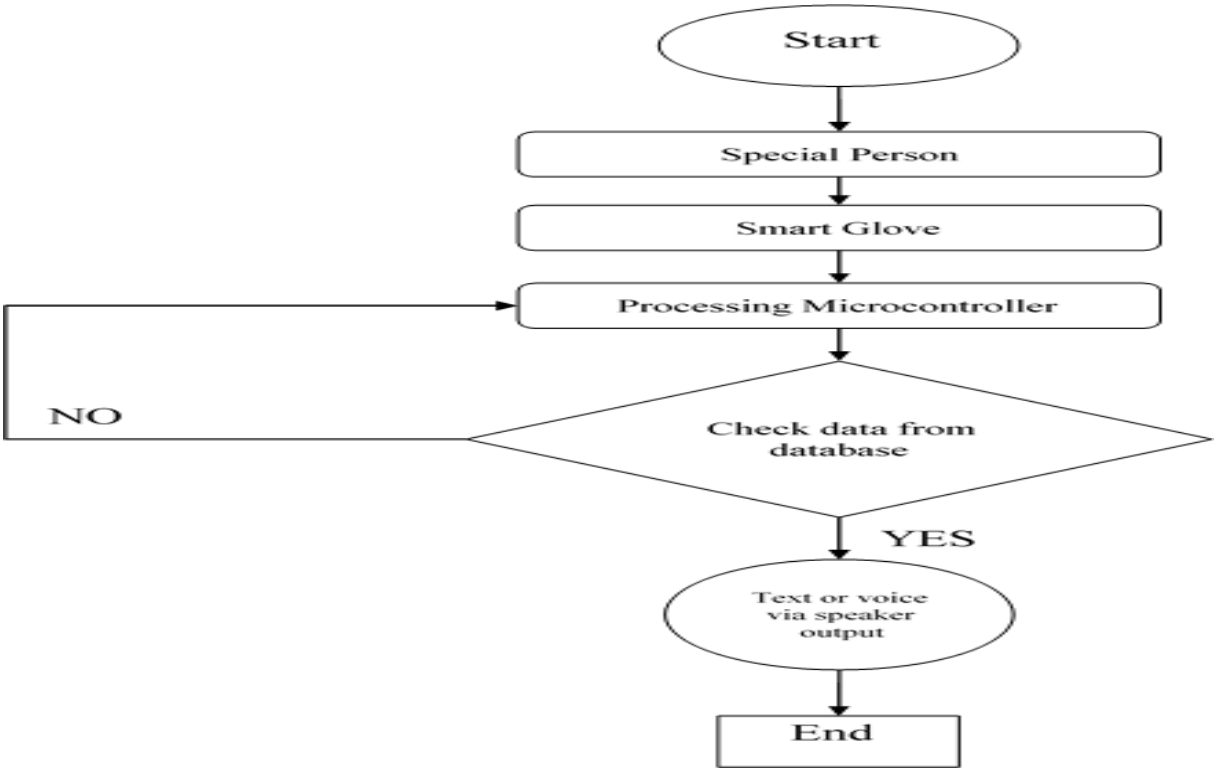
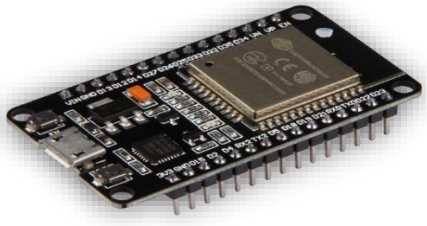


Figure 3: System Flowchart of Smart Glove

COMPONENTS DISCRIPTION:

NodeMCU-ESP32:

The ESP32 (Figure. 5) is a powerful and affordable device, developed by Espressif Systems Company in Shanghai, China, and it has a robust feature set. The ESP32 is powered by a 32-bit, dual-core Tensilica (Santa Clara, CA, USA) Xtensa LX6 microprocessor, which improves processing power and allows for multitasking and the effective completion of challenging tasks [23]. This system combines the ESP32 microcontroller with the MPU-6050. The MPU- 6050's SDL and SCL pins connect to GPIOs 21 and 22 of the Esp32, while the VCC and GND pins connect to the Esp32's 3V3 and GND pins. The Serial Clock Pin is a clock signal that synchronises data transfer between devices, whereas the SDA Pin transfers data. The ESP32's hardware consists of a smaller surface- mounted board housing the MCU and a circuit board with a USB controller. The ESP32 is programmed with the Arduino IDE. It acts as a dual inline package (DIP).



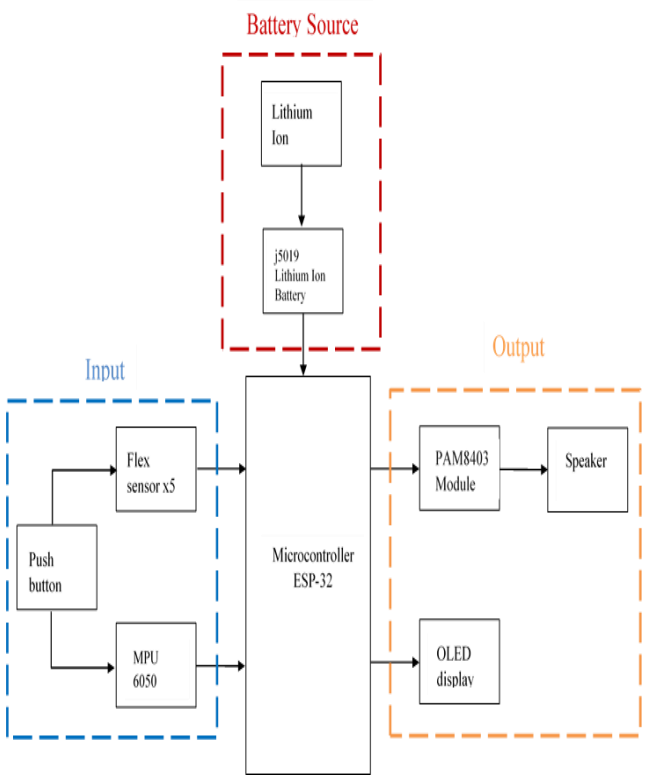
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Figure 5: NodeMCU ESP32 [24]

1) OLED Display Module:

OLEDs, or organic light-emitting diodes, are solid- state monolithic devices with 0.96" screens (Figure 6). Typically, they are composed of several organic thin films sandwiched between two thin-film conductive electrodes. The emissive OLED screens and the potent ESP32 microcontroller function well together. These displays are special because they don't need a backlight, which allows for a slimmer and more efficient design than LCD displays that rely on a white backlight. OLED screens are known for their superior image quality compared to LED and LCD screens, but they also have additional advantages. It is feasible to make



them transparent, foldable, flexible, and even roll- able and stretchable [25].



Figure 6: OLED Display module (SSD1306) [26]

j5019 Lithium Ion Battery Charger:

A portable and effective j5019 lithium-ion battery (Figure. 7) charger made especially

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for charging lithium-ion batteries. This charger guarantees a dependable and secure charging experience for small lithium-ion batteries because of its user- friendly design. The J5019 charger puts dependability and ease of use first, providing an easy-to-use way to maintain lithium-ion batteries charged and ready for use.

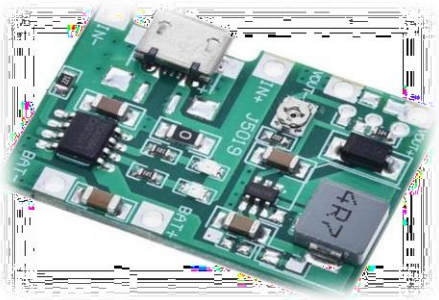


Figure 7: j5019 Lithium Ion Battery Charger [27]

PAM8403 Module:
The PAM8403 module (Figure. 8) is a compact audio amplifier system. To improve audio functionality, the PAM8403 module is seamlessly integrated with a speaker. The PAM8403 module is a crucial part of producing clean, clear sound through the attached speaker. It is renowned for its small size and effective audio amplification capabilities. The incorporation guarantees a strong and audible output in addition to facilitating gesture-based communication, improving the user experience overall [28].

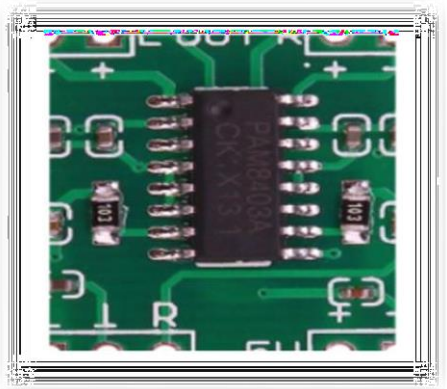


Figure 8: PAM8403 Module [28]

Sparkfun Flex Sensors:
SparkFun Flex Sensors as shown in Figure. 9, as its name indicates this sensor measures bending. This system uses a flex sensor to recognise hand gestures. The glove's fingers have these sensors attached. Flex sensors are similar to potentiometers, which are variable resistors. The floor of flex sensors is made of carbon and is attached to a plastic strip. The flex sensors' flat resistance is typically around ten kilo ohms. The resistance of the sensor changes with the degree of bending

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in the strips; this allows to measure accurate bend or deflection. As therefore, another name for the sensors is bend sensors. Since the resistance of the sensor is directly proportional to the bend it is also used as a goniometer [29].

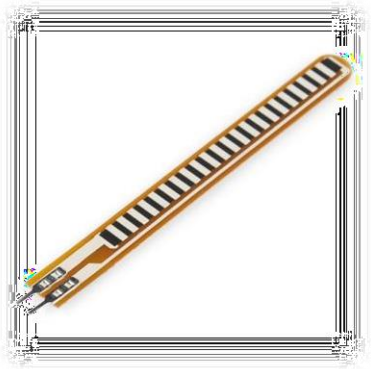


Figure 9: Sparkfun Flex Sensor[30]

Working Principle of Flex Sensor

The Flex sensor operates based on the bending principle. In this prototype, bending the sensors
causes an output of resistance that is proportional to the radius of the bend; the smaller the radius, the higher the resistance value. They have an output range of 0 to 5V and a 5-volt input requirement. Three pin connectors—ground, live, and output— connect the sensors to the apparatus. The resistor functions more in line with a variable resistor, whose bending changes as resistance changes. The resistance changes as the surface bends, and the bend is dependent on the sensor's surface linearity. The resistance is different—nominal—while the surface is fully linear. The resistance will be greater than the nominal value when unbent as the bend increases—for example, to 450. In one sentence, we can summarise the principle that "the smaller the radius the higher the resistance" in one line by noting that this bend continues to increase with a decreasing radius. Three bending degrees are shown below in Figure. 10: [31][32].

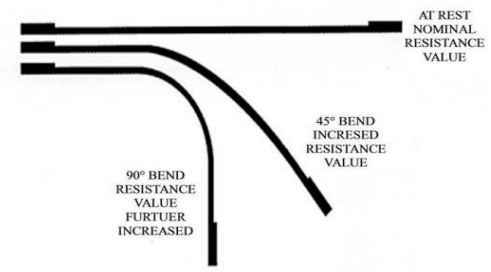


Figure 10: Sparkfun Flex Sensor Variation of Resistance with Degree in Bend[31]

Three instances of flex sensor bending are depicted in the picture above. The sensor's resistance is at its lowest value in case (1), where the bend is equal to zero, the nominal bend. (2) When the resistor is bent at an angle of 450 in case number two, the

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resistance is twice that of 00. (3) Similarly, the resistance is twice as great as it is at 450 and four times as great as it is at 00 when the bend angle is 900. Resistance varies with angle, increasing with increasing degrees and decreasing with approaching the nominal angle.[32]

MPU-6050:
A well-liked and adaptable accelerometer and gyroscope sensor module, the MPU-6050, as shown in Figure. 11, is frequently utilized in a wide range of electrical projects and applications. It is intended to deliver accurate motion sensing and orientation information, making it a crucial part of
projects involving robotics, drones, wearable technology, gaming controllers, and other areas.

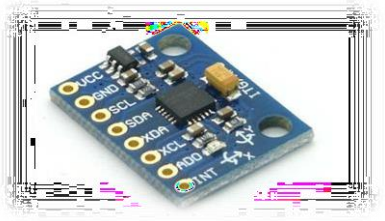


Figure 11: MPU 6050 [33]

The module's core is a low-cost, low-power 6-axis Motion Tracking chip that fits neatly into a 4mm by 4mm container. It includes a Digital Motion Processor (DMP), a 3-axis accelerometer, and a 3- axis gyroscope. It can measure both static and dynamic acceleration caused by shock, vibration, or motion, as well as rotation or angular momentum in all three dimensions. The gyroscope measures rotational velocity in rad/s, or the change in angular position over time along the X, Y, and Z axes (roll, pitch, and yaw). This allows us to determine an object's orientation, as seen in Fig. 12.

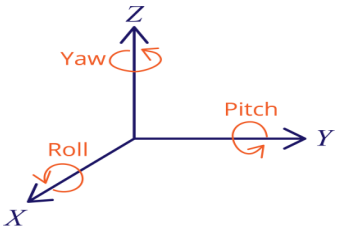


Figure 12: Gyroscope dimensions.

SOFTWARE:
Arduino IDE:
The Arduino Integrated Development Environment, or Arduino Software, is a collection of tools that includes a text editor for writing code, a message area, a text console, a toolbar with buttons for frequently used functions, and more menus (see

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Figure 13). It connects to the Arduino hardware and allows you to upload and communicate with software. The IDE programme supports a variety of operating systems, including Linux, Mac OS X, and Windows. The programming languages accessible include C and C++ [34]. Sketches are computer programmes developed with the Arduino Software (IDE). These visuals are made using a text editor and saved as files with the.ino extension. The editor includes
text replacement and search functions. When saving and exporting, the message section displays feedback and errors. The Arduino Software (IDE) generates text, including whole error messages and other data, and displays it on the terminal. The configured board and serial port are visible in the window's lower right corner. The toolbar buttons let you to generate, open, and save sketches, validate and upload programmes, see the serial monitor, and execute a variety of other operations.

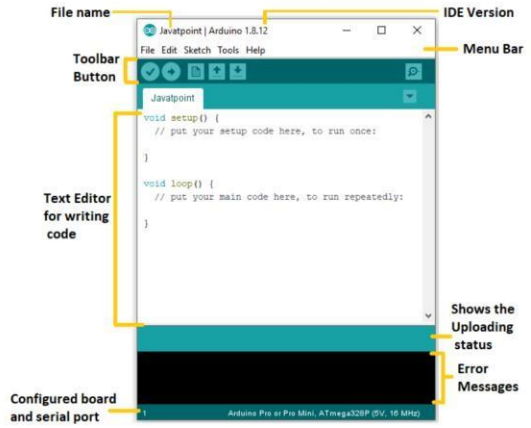


Figure 13: Arduino IDE

Libraries:

Libraries provide Sketches access to additional functionalities, such as hardware management and data processing. To utilise a library in a drawing, choose it from the Drawing > Import Library menu. This allows you to use the library to compile your sketch and then add one or more #include statements on top of it. Libraries require additional space because your sketch is also submitted to the board. If the sketch no longer requires the library, just remove the #include declarations from the top of your code. The reference section includes a list of libraries. The Arduino programming includes a few libraries. You can obtain more resources from the Library Manager or a variety of other websites [35].

Hardware Assembly:

In this section, every component is elaborated on how it is integrated to create a system that can generate text-to-voice based output using flex sensor signals acquired from special patients.

a) Setting up The ESP32 with Flex Sensors:

ESP32 microcontroller is used to design the project. It is responsible to acquire the analog data from the flex sensors and interprets to generate the data. It is done

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programmatically by using Arduino IDE. To program the ESP32 on the IDE, the board must be installed prior. There is an add-on on the IDE for programming the ESP32 with Arduino IDE. To install, go to **File>Preferences** then enter the URL of ESP32 into the Additional Board Manager. Once that is done the ESP32 board can be installed through Board Manager. Go to **Tools>Board>Board Manager…**

After setting the board, the flex sensors are wired to the microcontroller. Usage of flex sensors is a non-invasive method to acquire signals from a subject's hand movement. For smart glove project five flex sensors, one for each digit of the hand is used. The flex sensor has five numbers of pins connection (e.g. D32, D35, D34, D39, D36) The flex sensors acquire the signals and send it to the Analog pin of the ESP32 for manipulation. Ranges of the movements are monitored on the serial monitor and noted down. To process the acquired signals, an algorithm is created that analyzes the ranges of digit movements and specifies certain conditions on certain ranges. The circuit diagram for the project is given in (Figure. 14).

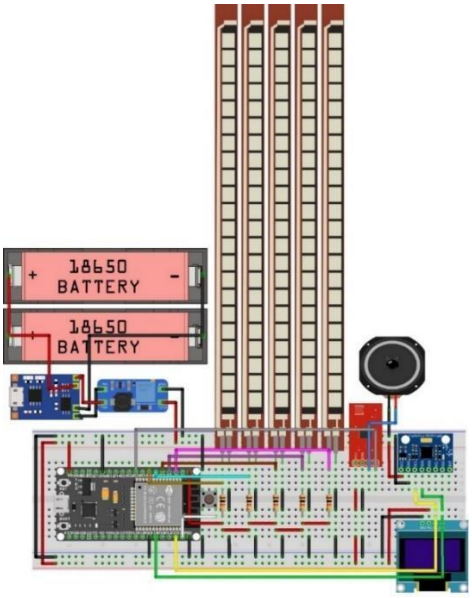


Figure 14: Circuit Diagram of Smart Glove.

Interfacing OLED:

The Adafruit SSD1306 library is used to interface an OLED display with an ESP32 microcontroller.

Start by utilizing the three-axis accelerometer of the MPU6050 to link the OLED display to the ESP32. Generally, connections are made by connecting the OLED's SDA and SCL pins to the corresponding GPIO pins (D21, D19) on the ESP32. After connecting, initialize the OLED display by showing the gesture text and include the library in the ESP32 code. This makes it possible to use the ESP32's capabilities to power the OLED display for a variety of uses, producing visual output as required.

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Output in the Audio Form:

In a small and effective package, the PAM8403 module amplifier produces remarkable audio output when paired with a speaker. This audio monster incorporates a powerful Class D amplifier for crisp and reliable sound reproduction. The PAM8403's low power consumption guarantees energy efficiency, and its small form factor makes it perfect for a portable smart glove. The PAM8403 module amplifier and speaker pair, with their uncomplicated design, enhance the audio experience. They offer a strong and effective solution for various audio amplification requirements in portable smart glove setups and other contexts.

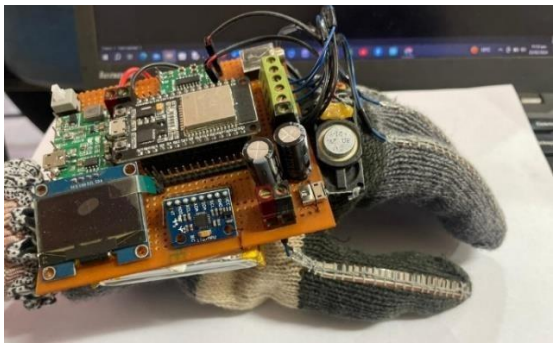


Figure 15. Smart Glove Prototype

The mentioned values in the table I ,have been computed against 10 trials of the glove. Each gesture was trialed on for 10 times, the times the glove returned appropriate output for the respective gesture was termed as success, whereas the ones with no output at all, even though the gesture was executed, were termed as errors. For instance, “You Are Welcome” when put through trials gave
7 successful against its 3 null/error outputs. Moreover, a complete gesture execution of each sentence taken from the American Sign Language took less than 10 seconds to produce its output.

Table I Accuracy table for gestures.

S.NO	Complete gestures	Total evnts occur	No of errors	Error in %
01.	Hello My Name Is Sara	10	0	0%
02.	I Cannot Hear and Speak	10	1	10%
03.	I Need Help	10	2	20%
04.	I Do Not Understand	10	0	0%
05.	I Am Feeling Sick	10	2	20%
06.	Thank You for The Help	10	1	10%
07.	It Is Nice to Meet You	10	3	30%

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RESULTS

Results reveal that the smart glove efficiently interprets a wide range of hand gestures, showcasing its proficiency in facilitating communication for the deaf and dumb. To ensure that everything worked and performed as intended, the prototype underwent intensive testing. After going through several testing cycles, the gesture recognition system produced results that were reliable and accurate. The results were displayed immediately on the integrated visual display following the performance of a series of preprogrammed movements (gesture). The prototype's audio output feature allowed users to hear responses simultaneously through the inbuilt speakers in the smart glove. The prototype demonstrates proficiency in recognizing and interpreting 20 fundamental gestures sourced from the American Sign Language dictionary. Although more gestures can be stored and recorded. According to the need of user.The smart glove prototype shown in Figure 15.

CONCLUSION

Smart glove for deaf and dumb person uses a combination of hardware and software components to recognise movements and provide an outcome. this system is created on American Sign Language (ASL) dictionary. Based on the results, it has successfully identified the gestures associated with the specific movement made by a special person. Since that the glove's detection capabilities have shown promise, an individual with physical disabilities can use it with ease to gain independence and communicate within their community. It can recognise every individual move that a finger bends in addition to the position of the hand when it is in the air. The future goals for smart glove encompass enhancing human- machine interaction, improving healthcare outcomes, and expanding their versatility for diverse user needs. Further plans include cloud connectivity for remote assistance and updates of smart glove, also expanding the gesture recognition capabilities by adding more gesture, enhancing accessibility for the deaf and dumb community.

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