



The Sign Language Interpreting Gloves

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ABSTRACT– This report's primary purpose is to provide a detailed overview of the sign language interpreting gloves project. It starts with an introduction, background and history of the deaf community to better understand the needs and issues of the D/deaf community. In the following literature review, the reader will have the chance to learn about the modern-days challenges faced by hearing-impaired people, broadly explained and elaborated. The psychosocial impact of assistive technology and its effectiveness in improving life quality is discussed next. A lack of new technologies assisting the D/deaf community is not hardly noticed. As elaborated in the previously mentioned chapters, sign language interpreting services are expensive and sign language interpreters cannot be easily booked. These and other findings gathered from the research and also by a survey conducted on a group of deaf individuals indicate that sign language interpreting gloves are the new free interpreters-to-be, and the answer to acquiring the so-wanted independence. Evaluated to have such a significant impact, building this assistive technology that can be easily accessed is the project's focus. The working principles, block diagram and flowchart are also described in the methodology section, where building, not one but a pair of gloves is also documented step by step. Finally, results, discussion and future work will tell us more about the importance of interpreting gloves to close the gap between both hearing and deaf communities.

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Introduction

Over 430 million people in the world have some degree of hearing impairment, which translates to 5% of the World's population. [1] These individuals identify themselves as a linguistic minority rather than a disability group. [2] For a community that does not accept to be labelled as disabled, the challenges are still great in a world that is not designed for primarily visual people who rely massively on their visual input to perceive the information around them.

Approximately 90-95% of deaf kids are born to hearing parents who often don't learn sign language and do not have a healthy relationship with their children since the communication is greatly lacking. [3] This language deprivation is not limited only in the family but also on the workplace. Individuals with hearing impairments can perform successfully on the job, but yet they are denied opportunities because of the stigma attached to the hearing loss.[4]

Often employees believe that accommodation is required to perform the job because of their impairment. [5] On the other hand, deaf individuals are often viewed as not intelligent or not bright due to the language barrier. Therefore, many people connect being deaf with being quiet or silent, which is not the case most of the times. Whereas deaf people are perceived as such for the mere reason that they do not speak the same language as the others, they do

have loud thoughts and opinions trapped inside of them, waiting to be released.

Furthermore, suffering from loneliness and depression is common in the deaf community where the sensation of loneliness prevails even in crowded rooms full of people. In addition to that, being misunderstood or misunderstanding what is going on is one of the main factors of withdrawal in these individuals.

Population who lives with hearing loss is expected to be 2.5 billion by 2030, from which over 500 million will have disabling hearing loss. Two decades later, in 2050, over 700 million are expected to have disabling hearing loss. [6] That means 1 in 4 individuals will have some degree of hearing loss by then. While such alarming numbers aren't always evitable or preventable, they highlight the emerging concern for inclusion and accessibility for this growing disabled community. [7]

In the Middle East, about 3% of the population suffers from hearing loss. Only in the United Arab Emirates, the century's most growing disability touches 4% of the population. [8] This increasing population of the hearing-impaired in the UAE reports unfair treatment because of their disability even though the country has signed the United Nations Convention on the Rights of Persons with Disabilities (CRPD). [9]

As the UAE is failing to make laws stronger and monitor the implementation of the CRPD mentioned above, disabled

people complain about how they are denied equal access to learning support in the university and how employers do not give them measures and tools to do their work.

Having such essential but unsolved problematics in the country, ushers the beginning and development of this project with the hope that technology will be the future assistant needed to improve lives and give equal opportunities to people despite their disabilities. Hopefully then deaf people will be treated with more dignity as rights holders that they are and given equal access to higher education and employment as law will not be the only thing granting them the right to be equal. Technology will also be there to help and change the stigma as people will find it easier to interact with this category and will subconsciously find them 'less disabled'.

Literature Review

A. Modern Times Challenges

Sign Languages are now a recognized language in majority of the countries worldwide either as a national language, regional language, official language, minority language or a working language. It is not seldom though that these signed national languages are symbolically attributed such title, nevertheless, there are practical implications too.[10] Because of the dual nature in perception towards this category as a linguistic minority group and disabled individuals, it is important to differentiate between implicit and explicit recognition. Implicit recognition acknowledges sign language when disability access is concerned, while explicit recognition provides access when dedicated language legislation is concerned.[11]

Therefore, daily challenges can be justified as following situations when little to nothing is audible while normal people may have never thought that makes life more difficult.[12]

Public announcements

Most of the time, it will be hard to recognize speaker announcements because the noise prevents hearing impaired individuals from getting the message right.

Slow talkers

People who interact with a deaf or hard-of-hearing person usually change to a slower form of speech, which makes it challenging to lip reading and leads to miscommunication.

Being in the dark

People with hearing loss rely mainly on visual stimuli to engage with people around them and on touch to get attention instead of calling their names. Whereas it's been problematic since the latest circumstances with COVID-19 as wearing a face mask can be an obstacle to verbal communication as it covers the mouth and much of the face, which removes the capability to observe lip movement and facial expressions.[13]

As a result, more difficult than usual for hard-of-hearing or deaf individuals.

Interviews and job applications

It can be challenging to get a face-to-face interview stage due to revealing their hearing situation on application forms, as recruiters see it as an extra effort to communicate with them. Also, telephone interviews. are inconvenient without interpreters.[12] They can be costly and hard to get in a short period as many interpreters don't make it on time. Moreover, interpreters of a lesser diffusion languages will charge more for their services. Korean, Finnish, Swedish, Icelandic, and Norwegian are some of the most expensive, making it harder for deaf and hard-of-hearing individuals to hire an interpreter and be hired smoothly as every other normal job applicant.

Nevertheless, health care language barriers when it comes to a flawed diagnosis interpretation, recommending the treatment, and providing medication instructions.[14]

Anxiety and depression

The risk of suffering from psychological problems is higher for hearing impaired individuals as sometimes they feel isolated. Whereas the efficient solution for this problem is talking to a therapist; however, finding one is not easy and is considered challenging.

Nowadays, technology is helping to close the gap. However, many deaf people consider deafness as their own unique culture and don't want pity from other communities.[15] They just want to be treated with respect. Therefore, we as individuals with hearing should respect that too.

B. Psychosocial Impact of Assistive Technologies

The deaf community is divided into two major groups. Those who identify as deaf (lowercase d) and those who identify as Deaf (uppercase D). The difference between the two is simple. The lowercase deaf is used to describe someone with a medical condition that deprives them from hearing the range of sounds a hearing person normally would. The uppercase Deaf refers to those who share a common language (sign language), a culture and are active members of the Deaf community.[16] The second group mainly has prelingual deafness (i.e., they were deaf before they learned any language and whose native language is sign language). They see nothing wrong with deafness per se. Having nothing to compare it to, they believe their only difference with the other part of society is the language they use to communicate. They are proud to call themselves Deaf and have high self-esteem.[17]

Deaf people who strongly identify themselves as a linguistic minority instead of a disability group do have other feelings towards new innovative technologies that are meant to help the deaf. The Deaf community believes that deafness should not be fixed and should be considered a beautiful ethnical difference and cherished as such.[18] From the perspective of linguists, every language brings its culture along with it.[19] With all the characteristics of a language – such as grammar, syntax, morphology, word-formation, vocabulary, and idioms (that do not derive from any other language), sign language brings its own culture to the table too.[20] This unique culture is a set of values, beliefs, history, traditions, and shared life experiences that are influenced by deafness, whose members' primary means of communication is sign language.[21] These members of the Deaf community who have first handedly experienced the politics of deaf

assimilation and who have been forced to speak and rebuked if caught signing until two decades ago are restlessly trying to preserve this culture, language, and history from what they think might harm it. And assistive devices such as cochlear implants or even interpreting gloves might be seen as such a threat. Yet not all deaf people view technology as a threat, but as a solution to their challenges instead. A living proof of that are individuals who share their life experiences with cochlear implants saying they wish they got them sooner.[22] which gave them the ability to make their lives easier. The Human Activity Assistive Technology Model (HAAT), as shown in figure-1- [23], is one of the first adoption measures for AT as it focuses on individuals existing abilities and the fulfilment of a task in context of a social setting.

In contrast, the measurement of Psychosocial impact can be related to isolation, education, and employment due to communication barriers.

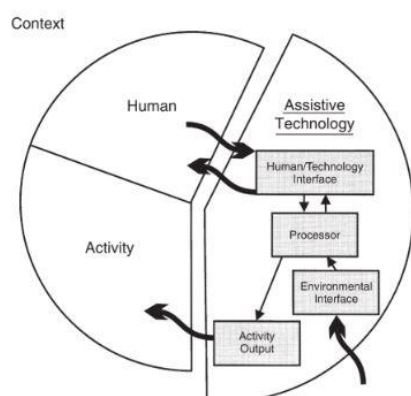


Figure 1. Human Activity Assistive Technology Model (HAAT)

Therefore, the adoption process of assistive technologies for deaf and hard-of-hearing people is a firmly relevant variable from the psychosocial impact derived from using the devices.[24]

As assistive technologies (ATs) can be a helpful intervention tool to mitigate the repercussions of hearing loss on people's daily activities and roles and improve adaptability, competence and self-esteem observed after their use. Moreover, the impact measurement can be helpful to predictors of the future abandonment of a device and promote the development of more effective devices to meet the needs of final users and improve their day-to-day functioning.

C. Effectiveness of Assistive Technology in Improving the Life Quality

Technology does provide a lot of support when it comes to the lives of the hearing impaired. Because of the facilitation that comes from technology that deaf or hard-of-hearing individuals can independently make emergency calls without having to rely on the help of their family members. Developing such technologies that are functional as well as accessible enables people who are deaf or hard of hearing to become active members of the society by boosting their education opportunities and involvement in business enterprise. It also provides opportunities for professional and personal advancement.[25] All the above-mentioned technologies discussed in the previous section support the deaf community in various ways to get along better in the

world and access a better hearing range needed for their daily life navigation.[26]

Regardless all positive impact that technology has had in this community's life, the Deaf often have negative experiences in the Hearing world, especially when it comes to education, literacy, as well as other problems raised by the lack of recognition and response to the environmental stimuli.[27]

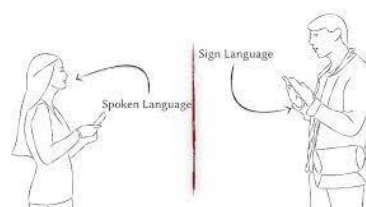


Figure 2. Differentiation between the Languages

Therefore, finding ways to make AT more helpful for hard of hearing or deaf people can be done by developing assistive Systems.[28] Including deaf participants in the process can increase the acceptance of the technology and provide better insight into their perspective about the communication barriers they face, as shown in figure -3- their point of view regarding the communication process.

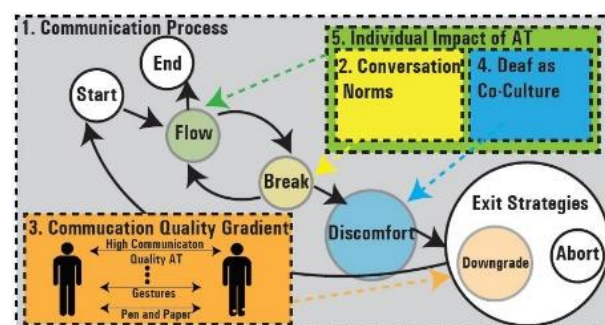


Figure 3. The Deaf Model of the Communication Process

On the other hand, the capability of translating to and from sign language by mobile systems using machine learning and electromyography to recognize the signs [29] or instrumented gloves (smart gloves) which will be thoroughly explained in the upcoming section and leverage depth cameras, including the development of animated avatars to help to show the signs.

This technology will make it more accessible to communicate between deaf and hearing people, especially during emergencies,[30] when available certified interpreters can be hard to find. At the same time, paramedics and doctors don't have the ability to sign and communicate.

D. Smart Gloves Technology

Sign language is the only available tool to help hearing impaired people communicate with each other. However, normal people still cannot understand sign language because it's not easy to learn due to its natural differences in sentence structure and grammar.[31] Any sign language in the world consists of three major components [32] as follows:

1- Fingerspelling level: a technique used to spell words letter by letter.

- 2- Word level: used for the majority of basic communication.
- 3- Expression level: facial expressions, tongue, mouth, and body position, which make the language easier to comprehend.

Therefore, there is a need to create a system that can help translate sign language into voice and vice versa to ensure effective and accessible communication between different communities.

Many approaches have been proposed for “Hand Gesture Recognition System using Image Processing” in recent years, by using a modified SIFT algorithm to process the digital image, which can provide results in real-time; however, it requires expensive materials. Using the SURF (Speed up Robust Features) algorithm and implementing the system in MATLAB is also a possible method.

Another approach uses a sensor-based technique comprising of flex sensor, tactile sensors, and accelerometer to translate sign language gestures to both text and auditory voice.[33]

Meanwhile, there are three main types [32] of smart gloves:

- 1) DG5-Vhand gloves as shown in figure-6- embedded accelerometer, gyroscope, and magnetometer with a number of finger sensors and approximately Price \$3000.
- 2) 5DT gloves as shown in figure-5- that consist of wireless interface cables and a wireless data transmitter with a wireless belt plate.
- 3) Cyber gloves as shown in figure-4- are supported by each wireless receiver and cost approximately \$30,000.



Figure 4. DG5 Vhand Glove



Figure 5. Cyber Glove

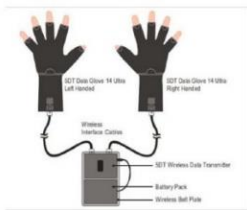


Figure 6. 5DT Glove

Currently, existing gesture recognition techniques [34] can be divided into two main categories based on the method:

- A) - Computer vision-based method
- B) - Sensor-based method

A vision-based method uses a camera interfaced with the user's cap and on the desk as the user sits in a fixed place so that the system can recognize the gesture accurately.[35] However, the accuracy of an image processing algorithm can be diminished by the effect of the environment's lighting conditions.

A sensory glove translator is a framework underneath the expanded communication's magnificence as shown in figure-7- explaining how signs can be translated into text or speech.

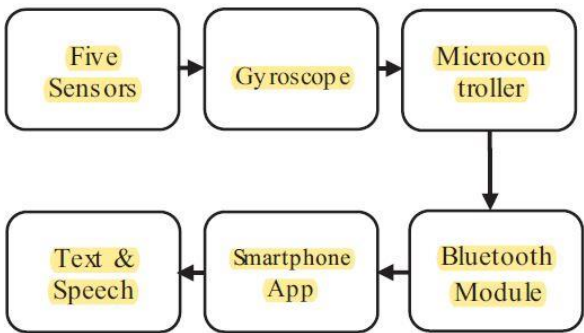


Figure 7. Sign Language Converter

Augmentative and Optional Correspondence (AOC) is a conspicuous phase in the development of help institutions for humans with disabilities, especially those with veritable preparation.[36] The sensor is the leading player in the hand gesture, which involves measuring the bend value, position, rotation, or movement. That's why the system's main advantage is the fast response in real-time applications.

Other researchers proposed a model that performs better recognition of signs using a combination of Artificial Neural Network (ANN) and Support Vector Machine (SVM) algorithms of machine learning. This combined algorithm produced better results than the hidden Markova model (HMM).[37]

In another method, researchers developed a sign language recognition system using a portable Accelerometer (ACC) and Surface Electro Myogram (sEMG) and used the Support Vector Machine (SVM) algorithm to obtain better results than real-time gesture recognition.[38]

An artificial neural network can translate American sign language into alphabets. A sensory glove translator called a cyber glove used for data collection [39]. However, inter-class complexity was increased to a large extent, so Convolutional Neural Network (CNN) algorithm was used to solve this problem. Depth images were captured using a high-definition Kinet Camera. Finally, obtained images were processed using CNN to get alphabets and perform real-time sign detection.[40]

In conclusion, many image processing and sensor-based techniques have been applied for sign language recognition. With the advent of time, recent studies have shown the latest framework for sign recognition.[41] Chin-Hao proposed an

American Sign Language recognition system with motion sensors that considered to be better than a cyber glove embedded with Kinect camera .[42]

In close with the progression of time and the new advancements of wearable innovation, it is currently possible to actualize valuable and incredibly innovative methods to help humanity in meaningful ways.

Methodology

This project working principle is experimented with a mixed-method and consisted of the combined hardware and software design. In contrast, ASL translation is divided into three main stages:

- Recognizing sensor's values
- Processing the values
- Displaying the sign in android application

The hardware part will mainly depend on five flex sensors in each glove, as shown in figure-8-.



Figure 8. Fixed Flex Sensors on Gloves

The flex sensor measures the bending of fingers according to gesture and outputs change in resistances corresponding to the amount of bending.

While an accelerometer sensor tracks the movement of the hand and measures the linear movements of hand in X-axis and outputs different values of X corresponding to the movement in X-axis. All the data from sensors are then processed on ESP-32 microcontroller which involves combination of all the sensor outputs in order to match the resultant output with pre-stored values of different signs regarding the alphabets and specific words. For this, appropriate ranges are set for each alphabet and the words that can be recognized with single hand based on the measured data obtained from repeated measurements.

The processed data is then transferred through Bluetooth in string format while the Android mobile usually reads data in bytes format then converts them into string. Finally, the string is converted into text using the mobile application.

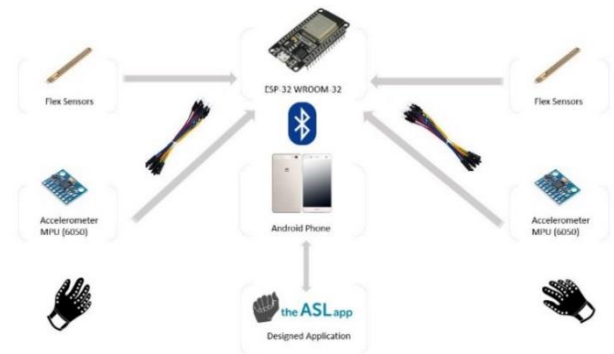


Figure 9. Block Diagram

This overall system is mounted over a normal glove for easy handling and recognizes the hand gestures accurately.

Flow Chart Of The Sign Language Interpreting Gloves

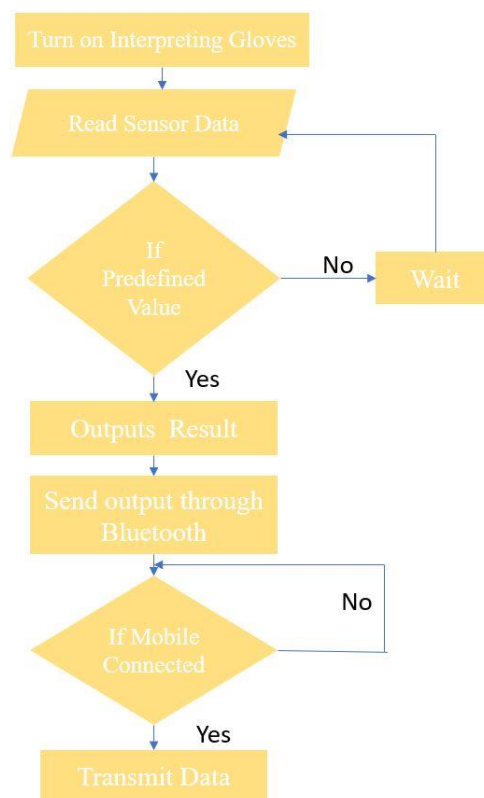


Figure 10. Flowchart of Transmitting Module

Flow Chart For Android Application

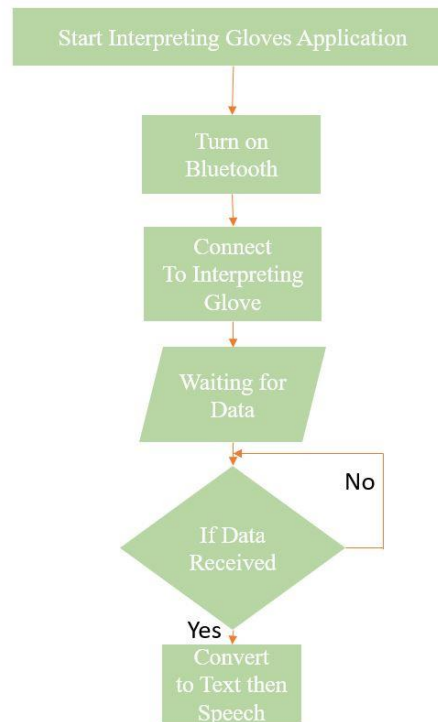


Figure 11. Flowchart of Receiving Section Module

Result

The hardware in this project includes five flex sensors in each pair a rotation sensor MPU6050 connected with ESP32 through Bluetooth and an output subsystem with an android application (Bluetooth Serial apps used for testing). Selecting the correct type of sensors for measuring the finger joints' bend value is crucial. Here, flex sensors have been chosen that are essential for taking the user's input.

Figure -12- shows the final developed glove of the submitted framework. It shows ten flex sensors mounted on each glove's top of each finger to measure the bend resistance.



Figure 12. The Final Prototype

The outcome of this project was to detect American Standard sign language alphabets and some words whereas successfully displayed into text then convert it to speech through an app on an android phone, which can help speech

impaired and hard of hearing people communicate with hearing people. It can easily use by wearing gloves by the user and making different gestures with fingers, so each flex sensor can detect the values through a range of resistances and take different ranges for each position.

For convenience, a couple of alphabets have been tested, 'B', 'C', 'D', and 'A' with sign language showing each alphabet in a line as shown in figure-13- using Serial Bluetooth Terminal.

Another approach was displaying a name letter by letter, as shown in the figure below and letters in sign language figure-14-.

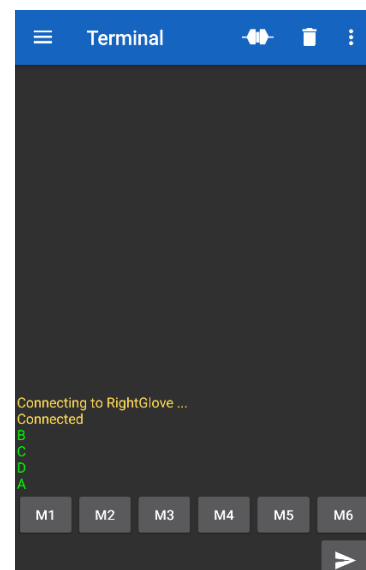


Figure 13. Bluetooth Serial Displaying the Letters after Reading the Gesture from the Glove

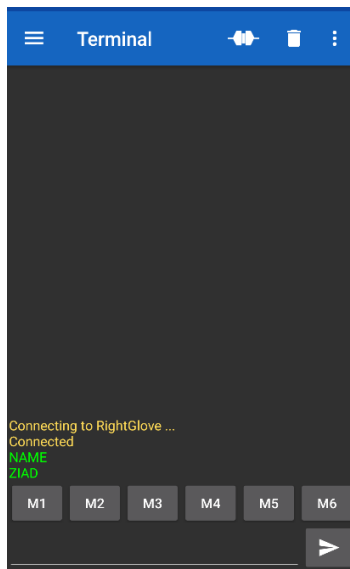


Figure 14. Bluetooth Serial Displaying a name letter by letter

On the other hand, text-to-speech conversion has been applied as well shown in figure-15- using Arduino Bluetooth Text to Speech to print the following words and alphabets.

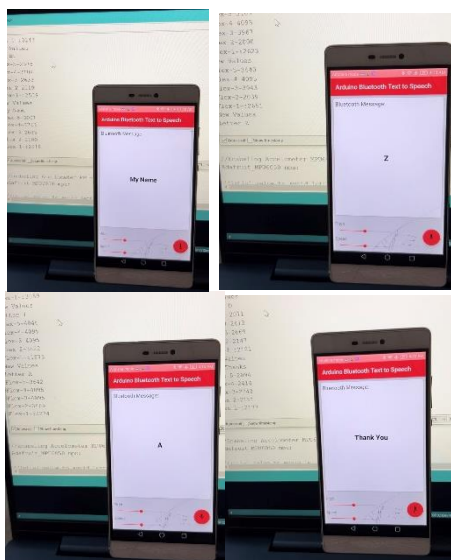


Figure 15. Bluetooth Converting Text to Speech after Reading the Gesture Values from the Interpreting Glove

Eventually, the speed and accuracy of the system were tested, and the outcomes were positive.

A detailed description of the cost and quantity of the components used in the proposed project shown in the table-1-

Table 1. Estimated Cost of the Project

Description	AED
ESP-32 WROOM-32 Microcontroller x2	65
Flex Sensors x10	370
Resistors	10
Accelerometer MPU (6050) x2	45
Cycling Gloves	55
Power bank x2	40
Jumper Wires	10
Total	595

Discussion and Future Work

The submitted method performs well with different users. It also can add other datasets of basic alphabets as shown in figure-16- and signs from other sign languages. Furthermore, creating a corresponding dataset for complex gestures will be one of the critical challenges; however, the benefit of including it will make it possible to generate words directly from a single posture instead of typing alphabets to form words.



Figure 16. Displaying Alphabets A, B, C, D, I, L, Y, H, V in Sign Language

Nevertheless, it will also have some limitations in detecting some alphabets and words while changing the user as the range of sensor values will be changed from user to user.

Figure-17- showing the accuracy of alphabets tested by user.

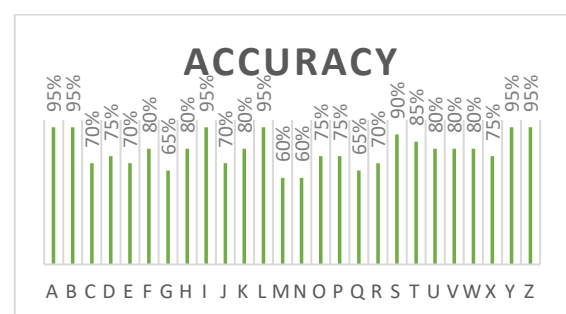


Figure 17. Accuracy of Gesture Values for Alphabets Tested by One User

However, still, this can be fixed by providing more flexible gloves for each user and the correct size. Then each dimension of the glove will have the same accuracy values. According to each measure, the acceptable range of sensors can be taught to the microcontroller accordingly.

Further, plan is to build an authentication system to create a better front-end mechanism and also intend to provide users

with the option of generating their own custom gestures for quick communication.

On the other hand, future scope plans use cameras to capture facial expressions and Paired system with a fitness sensor to monitor the individual's health.

Table-2- shows the range of the flex sensors of alphabetical data according to one user who tested it.

Table 2. Flex Sensor Values Range of Alphabetical Data

<i>Alphabet</i>	Flex-1-	Flex-2-	Flex-3-	Flex-4-	Flex-5-
A	2200~2400	3200~3400	3900~4095	3900~4095	3800~4000
B	2600~2800	2100~2300	2600~2800	2400~2600	2000~2200
C	2300~2500	2500~2700	3700~3900	3100~3300	2500~2700
D	2400~2600	2100~2300	3900~4095	3900~4095	3400~3600
E	2800~3000	3100~3300	3900~4095	3900~4095	3000~3200
F	2100~2300	2400~2600	2800~3000	2300~2500	2100~2300
G	2300~2500	2300~2500	3900~4095	3900~4095	3600~3800
H	2600~2800	2000~2200	2500~2700	3900~4095	3000~3200
I	2700~2900	3400~3600	3900~4095	3900~4095	2000~2200
J	2900~3100	3400~3600	3900~4095	3900~4095	2100~2300
K	2400~2600	2000~2200	2900~3100	3900~4095	3100~3300
L	2200~2400	2100~2300	3900~4095	3900~4095	3600~3800
M	2600~2800	3000~3200	3700~3900	3900~4095	2800~3000
N	2300~2500	2900~3100	3900~4095	3700~3900	3000~3200
O	2700~2900	3100~3300	3900~4095	3900~4095	3200~3400
P	2500~2700	2000~2200	3000~3200	3800~4000	2900~3100
Q	2400~2600	2200~2400	3900~4095	3900~4095	3300~3500
R	2700~2900	1900~2100	2600~2800	3900~4095	2900~3100
S	2800~3000	3500~3700	3900~4095	3900~4095	3500~3700
T	2200~2400	3200~3400	3900~4095	3900~4095	3200~3400
U	2500~2700	1900~2100	2400~2600	3900~4095	2900~3100
V	2600~2800	2000~2200	2600~2800	3900~4095	3100~3300
W	2600~2800	2000~2200	2500~2700	2500~2700	3300~3500
X	2800~3000	2800~3000	3900~4095	3900~4095	3500~3700
Y	2000~2200	3500~3700	3900~4095	3900~4095	2000~2200
Z	2500~2700	2000~2200	3900~4095	3900~4095	3300~3500

Conclusion

As indicated from the accumulated data, the involvement of technology in the matter is vital for the integration and professional development of deaf individuals. Hence, sign language interpreting gloves as the core of this project, gave us a sense of closure of what to expect from modern technology.

Using just five flex sensors and an accelerometer with ESP32 in the gloves promotes freedom and independence by providing easier and smoother communication to bridge both deaf and hearing communities. This technology will not only fight the stigma that has been attached to the hearing-impaired, but it will also create more opportunities and build deeper and stronger relationships.

It is realistic to say that with an expanded vocabulary over the years, these gloves can do wonders and possibly for the first time, it could lesser the need for a physical sign language interpreter or entirely omit it with time.

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