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Innovative study of an AI voice based smart Device to assist deaf people in understanding and responding to their body language

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Abstract—*Human beings can communicate with one another via natural language channels including words and writing, or through body language (gestures) like hand gestures, head gesticulations, facial expressions, lip motion, and so forth. Learning to read and write in normal language is essential but knowing sign language is equally essential. Individuals who are partially deaf rely on sign language as their primary mode of communication. People who have hearing impairments have difficulty communicating with those who do not have hearing issues if they do not have access to a translator [1]. This is why the deaf community will benefit greatly from a technology that understands sign language especially hand gestures. Even though mobile technology is rapidly evolving and becoming incredible, there has been little technological advancement and development for artificial intelligence voice-based smart devices that can assist deaf people in understanding and responding to their body language. When combined with learning algorithms, ubiquitous sensing may be used to integrate all of the body language information. As with spoken language, body language has a variety of libraries and each communication is distinct [1]. With my technology, each user can program their device to detect and comprehend their hand gestures, allowing it to recognize and interpret those signals into a voice. It provides users with full command over their sign language library as well as their spoken communication, making it helpful for anybody who has difficulty hearing or speaking. Studies to investigate ways of bridging this breakdown in communication for the deaf have been in progress, with more to come. There are now available stand-alone tools and apps that may aid in the interaction among people who are profoundly deaf [2]. This is why this research aims to develop artificial intelligence (AI) voice-based smart devices that would make use of current technology to demonstrate how it can assist individuals with hearing difficulties. All of the items used in this project are commercially available especially, hearing components, microcontrollers, LCD module, Audio amplifier, wiring, and open-source code libraries.*

Keywords: *Artificial intelligence, Automation, flex sensors, microcontroller, body language, deaf people, LCD module, open-source code libraries*

I. INTRODUCTION

Speaking, writing, listening, and understanding human language is one of the most difficult and innovative tasks artificial intelligence (AI) can accomplish. Deafness is a medical condition as well as a cultural identity. The communication preferences and strategies of each individual are unique to that person [2]. Some people are completely reliant on sign language, while others rely on lipreading and the ability to understand some spoken language. Individuals' communication skills are influenced by a variety of technical factors, including hearing aids and cochlear implants, as well as their inherited traits. Additionally, there is a wide range of English literacy comprehension understanding among all of these factors [2]. Many aspects of it are linguistic, and they are often affected by the individual's chosen sign language modality. Independent of the factors and literacy comprehension levels, all people have one characteristic: they are motivated by the fundamental human desire to communicate regularly [3].

For the most part, when people are face to face in daily crowded places, the spoken word is naturally the preferred mode of communication. As a result, individuals who are deaf are placed at a clear disadvantage right away. Social interactions between deaf and hearing people are frequently problematic, particularly when one doesn't comprehend the other. Gestures are made, yet often fall short of conveying the desired message. Others spend time searching for a phone, papers, and/or pencil, but when one has eventually located, there is the possibility of linguistic misinterpretation of the language [2,3]. With today's technological advancements, a remedy should be created to contribute to the success of these uncomfortable encounters and to enable greater flexibility in communication exchanges to be successful.

Millions of individuals all over the globe use sign language to interact, and they depend on a friend or a family to translate their signals for them when they are unable to speak. A total of 70 million individuals are profoundly deaf, with an additional 230 million people having hearing impairment or being unable to communicate due to illnesses including autism or stroke [4]. Additionally, because 90% of deaf children are born to normal parents who can only understand sign language n to a lesser extent, communicating may be a major issue. According to consumer research, just 2 percent of individuals with hearing problems have access to the communication technologies they need since it is either too costly or cannot be tailored to their specific requirements [4]. Our product's uniqueness in the industry is because it may be customized while still being reasonably priced. Even though they are cutting-edge tools, their usefulness, boot-up time, and/or operating systems are cumbersome. However, the most significant disadvantage of these gesture-based systems is that they do not address the capacity to properly understand sign language [5]. My suggested gadget will have many different components, including a set of sensors that will detect hand movements and recognize them. This presentation will examine the design and development of a one-of-a-kind gadget that will assist deaf individuals in reading and understanding body language.

II. PROBLEM STATEMENT

The main problem that this article will address is the development of an artificial intelligence voice-based smart device that can evaluate the impairment of deaf individuals to recognize and respond to their body language. The main problem that this article will address is the development of an artificial intelligence voice-based smart device that can evaluate the impairment of deaf individuals to recognize and respond to their body language. The demand for voice assistants operated by companies such as Amazon, Google, and Apple have increased significantly in recent years [6]. An analysis of data from the Smart Audio Report indicates that smart speakers have outpaced the use of smartphones and tablets in the United States [6,7]. Nonetheless, for the deaf population, a future in which gadgets are largely operated by voice presents difficulties. The rhythms of deaf people's speech are seldom picked up by speech recognition software. Furthermore, a loss of hearing is a significant barrier to effective communication utilizing voice-based assistants [7]. Software created by Google may open the door for smartphones to read sign language if it is approved by the Federal Communications Commission [8]. The technology company has not created a product of its own, but it has released algorithms that it hopes will be used by developers to create their applications. Until recently, this kind of software was exclusively available for use on personal computers. Advocacy groups from the hearing-impaired community, on the other hand, have applauded the decision, but they caution that the technology may have difficulty understanding certain conversations [9,10]. Designs and user-friendliness of the applications should satisfy the usability and communication requirements of the target demographic from a two-way communication perspective. My proposed AI voice-based smart device will be one that can serve as both a voice-to-text and a text-to-voice translator while also streamlining conversations without adding any further uncertainty or reluctance. It will be simple to use in terms of functionality, and it will be straightforward to operate.

III. LITERATURE REVIEW

A. *Assistive technology*

When it comes to information transmission, assistive technology comprises a wide variety of hardware and software tools that allow a person to receive information in the format that is most convenient for them. These technologies for deaf people may include a variety of different things such as cochlear implants, loop systems, assistive listening devices, FM technologies, accessible telephones/videophones, visually warning systems, and much more [11]. Understanding the value and limits of various assistive technologies can be beneficial to both organizations and people who may make use of such technology in their daily lives. Particularly relevant is the case when organizations are looking to buy technology that is suitable for a broad variety of consumers [11]. The use of assistive technology is essential to create two-way communication between deaf, mute, and normal individuals in situations when none of them is required to learn sign languages. It is proposed in this article that the deaf and mute may communicate freely, without the need for sign language, using a new communication assistance system. When neither of them understands sign languages, deaf and mute individuals and normal people often interact with each other via visual cues and short words when neither of them does [11]. These brief exchanges are mostly focused on a few situations or keywords that may be visually distinguished from one another. Again, these keywords may be categorized based on syllables for the goal of producing vibrotactile responses that make it easier to understand what is being said [11,12].

B. *Artificial Intelligence (AI)*

Artificial intelligence (AI) enables computers to learn from existing experiences, adapt to new information, and perform tasks that are similar to those carried out by humans [12]. The vast majority of artificial intelligence applications that users know of today – ranging from chess-playing robots to self-driving vehicles – are primarily reliant on deep learning and computational linguistics [12]. Computers may be taught to do particular jobs by processing huge quantities of data and detecting trends in the data. This is accomplished via the use of various technologies. Machine-learning technologies have the potential to substantially reduce the communication obstacles that deaf or hearing-impaired persons have when interacting with other groups, thus promoting social inclusion for these individuals. Recent advancements in both sensing technology and artificial intelligence algorithms have opened the way for the creation of a broad array of applications aimed at meeting the requirements of the deaf and hearing-impaired populations [12,13].

C. *Application of body language by the Deaf community*

One significant cultural asset for deaf people is their native language, American Sign Language (ASL) [13]. The majority of Deaf individuals spend the bulk of their lives with persons who do not understand American Sign Language (ASL). It is only when Deaf individuals are in the company of other Deaf people that all communication barriers are dismantled and broken down [13]. The fact that ASL is a visual language is apparent to the majority of people. That the visual aspect of language affects compliance requirements is not immediately apparent is something that should be considered. There is no need for facial expression between the speaker and the listener while speaking spoken languages. Human beings don't seem to spend much time gazing at each other at all. Making eye contact over extended lengths of time is not something we are used to. In addition, we often allow background sounds to distract our attention away from the task at hand. In a signed interaction, the "listener" should constantly gaze at the "speaker." It is considered disinterest by the Deaf community when eye contact is interrupted or nonexistent [13]. Since the majority of hearing people may not openly and efficiently utilize their body and face for communicating, Deaf people perceive hearing people's communications as dull and devoid of emotion [13]. The use of facial expressions and body language are essential components of American Sign Language. Deaf individuals have a remarkable capacity to understand and interpret nonverbal communication, which they may utilize to their advantage. They can detect even the smallest of face and body motions. The use of "touch" is an essential element of body language that should not be overlooked [13,14]. Deaf culture makes use of physical contact with another person to welcome, bid farewell, draw more attention, and convey emotions.

Deaf people literarily peaking use their eyes to listen. A deaf individual can't gaze at an item while simultaneously listening to you explain how to utilize it. Do not speak until you make direct eye contact with the Deaf individual. A sign language interpreter will be used by a large number of Deaf individuals [14]. You must address the Deaf person directly rather than via an interpretation, and one should keep eye contact with the Deaf person. The fact that the Deaf person will be gazing at the interpreter rather than at another person will make anyone feel uncomfortable, but it will be recognized and welcomed by the Deaf person.

D. Sign language technologies

When it comes to communicating with other people, sign language (SL) is the primary method of communication for hearing-impaired individuals and other groups. It is conveyed via both manual (body and hand movements) and non-manual (face expressions) characteristics. All of these characteristics are combined to create utterances that communicate the meaning of words or statements [14]. Understanding and being able to record and comprehend the relationship between utterances and words is critical for the Deaf community's ability to lead us toward a time when automated translating between utterances and words is possible [14]. In recent years, researchers have recognized the need for the development of sign language technology to assist hearing-impaired individuals in communicating and socially integrating into their communities. Even though the advancement of such innovations can be extremely difficult owing to the inclusion of multiple sign languages and a scarcity of large annotated datasets, recent advances in artificial intelligence and machine learning have made significant strides towards automating and improving such systems [14,15].

Innovations for sign language communication include a broad range of applications, varying from the capture of signs to their realistic depiction, all to facilitate interaction between hearing-impaired individuals as well as between the deaf community and people who can speak. Furthermore, the reliable capture of body, hand, and mouth gestures using suitable sensing devices in either marker-less or marker-based settings is the goal of sign language recording [15]. Because of the limitations of existing sensor accuracy and classification capabilities, as well as the fact that occlusions and rapid hand motions pose major difficulties to the correct capture of signs, the precision of sign language recording systems is presently restricted. It is necessary to build strong machine learning algorithms to reliably categorize individual expressions into single signs or continuous phrases to perform sign language recognition (SLR). The absence of large annotated datasets, which has a significant impact on the precision and applicability capabilities of SLR techniques, as well as the challenge in detecting sign limits in continuous SLR situations, are the primary constraints of SLR at present [15].

By contrast, sign language translation (SLT) encompasses both the interpretation of sign languages and the interpretation of sign and spoken languages. It is the goal of SLT techniques to enhance communication among individuals who sign or communicate in multiple languages [15]. SLT techniques use sequence-based machine learning algorithms to do this. The problems in SLT are attributable to a shortage of multilingual sign language datasets, and the inadequacies of SLR techniques, which is particularly problematic when considered that gloss recognition (done by SLR techniques) is the first stage in the SLT methodological approaches' evolution [16]. Ultimately, the correct depiction and replication of signs utilizing virtual avatars or signed video methods are a part of sign language representations. At the moment, the Deaf community considers avatar motions to be unnatural and difficult to comprehend owing to errors in skeleton posture capture and a lack of lifelike characteristics in the look of avatars.

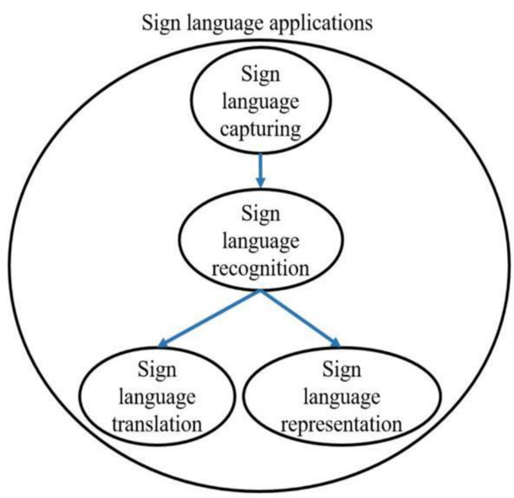


Fig i: Sign language applications

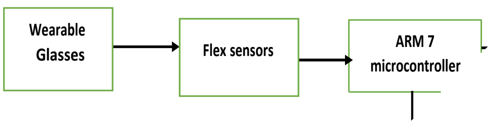
As shown in Figure 1, sign language solutions are interconnected in a manner that has an impact on one another. It is critical for the success of machine learning algorithms, which are responsible for the strong identification of signals, that precise extraction of hand and body gestures, and also face expressions, be performed with great accuracy. Furthermore, the accuracy of sign language recognition has a considerable influence on the performance of sign language translation and visualization techniques, as well as the effectiveness of sign language translating and display approaches [16]. The advancements in sensory devices and artificial intelligence have opened the way for the creation of sign language apps that may significantly improve the quality of life for hearing-impaired individuals in their daily activities.

E. Proposed AI-based Smart Device

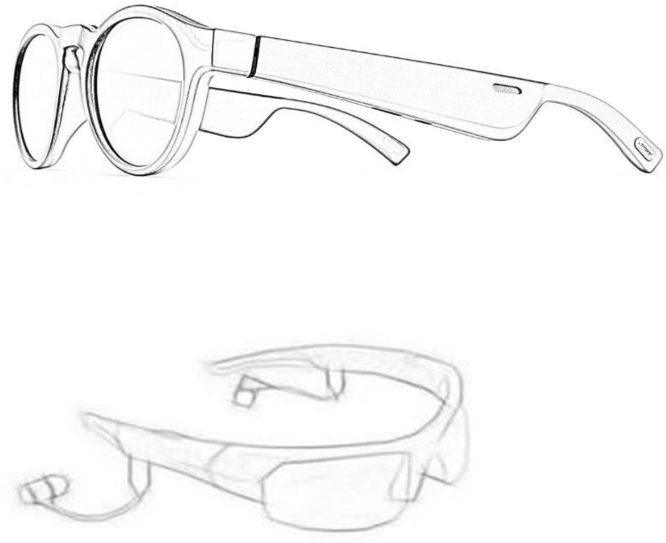
My proposal is based on the rationale that a deaf person can be able to hear what they see through an AI voice-based smart device. This is a device that will read body language which is hand gestures. Hand gestures are often used by deaf individuals to interact with one another in everyday situations. The fundamental concept behind my proposed device is the capture of these hand movements using sensors installed inside the device and the processing of the signal into a voice. To monitor hand gestures, my device makes use of flex sensors and Inertial Measurement Units (IMUs) which are connected to a microcontroller on the motherboard. The microcontroller contains the CPU, memory, and AI programmable input/output peripherals [16]. The flex sensors are utilized to detect the bending of the fingers as well as the direction of the hand in space. The flex sensors are used to collect 3D body language pictures by monitoring the movements of the subject with the help of an infrared sensor on the device.

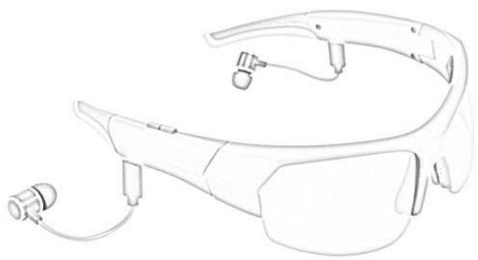
To detect the features of the hand, the system on this gadget makes use of image analysis, human-computer interaction, and neural network methods. This method will convert a video of a daily, regularly used proper sentence gesture into a text, which will subsequently be converted into audio. Many image processing procedures will be used to identify the form of the hand from a sequence of continuously captured pictures. The Haar Cascade Classifier will be used to determine the translation of signs and the meaning associated with them. At the end of the process, the visual text will be transformed into audio using voice synthesis. The major components of this device are shown in the diagram below.

Components in my proposed device

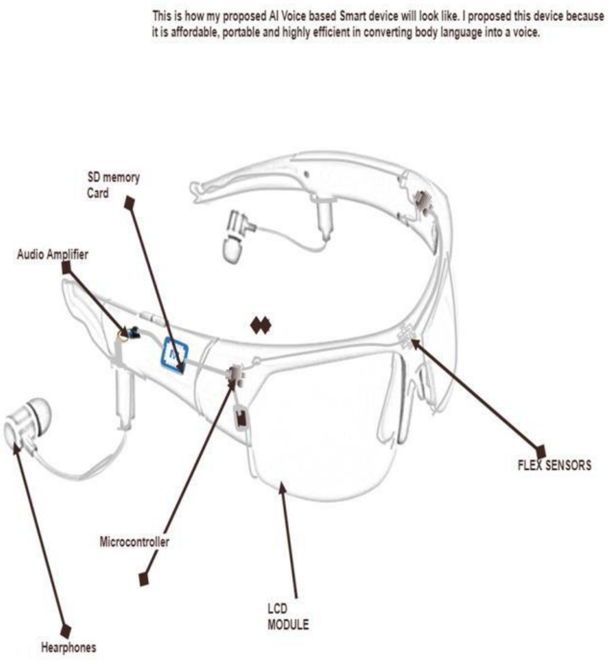


SKETCHES OF MY PROPOSED SMART DEVICE





FINAL DIAGRAM



The sketches and final diagram above show the proposed system architecture; the structure is mainly comprised of various components, incorporating flex sensors, an ARM 7 microcontroller, an LCD, an SD card, an audio amplifier, and a speaker. Flex sensors provide data streams depending on the extent and quantity of flex generated by the sign made by a deaf person interacting with the platform employing language for communication. The first module (input) collects signs made by a deaf person connecting with the device utilizing sign language. For this system, a collection of signs that represent are used to depict the words is used as the benchmark datasets for the device. It is the ARM 7 Microcontroller that receives and processes the output transmitted signal from the flex sensor, which is then transformed into digital data for further processing. The analog outputs from the sensors are then sent into the ARM 7 microcontroller's built-in ADC, where they are processed. These analog measurements are subsequently converted to digital format and saved in the microcontroller's internal RAM. A comparison between these signals and the check on the database contained in internal program memory will be performed by the microcontroller, with the reading that is adjacent to the look-up database being selected by the microcontroller. Once this is done, the microcontroller will scan the SD card for similar.wav files. Rather than using the traditional glasses, I've opted to use the LCD module instead. This text will be shown on an LCD screen and played back via a speaker. A person who is deaf or hard of hearing may communicate effortlessly with the help of these wearable devices.

F. Rationale on how it works

Flex sensors are embedded within the frames of the wearable glass, which run the length of each frame. The flex sensors provide a flow of data that changes in frequency according to the body language. Each sign has an already stored database of words which the microcontroller will compare and complete the match. The extent and processing of the data generated by the sign are determined by the digital signal provided by the flex sensors. For this technology, a collection of symbols representing words serves as the data source. It is the ARM 7 Microcontroller that receives and processes the outputs of a digital signal from the sensor module, which is then transformed into electronic information for further processing. A comparison between these measurements and the check database kept in internal memory space will be performed by the microcontroller, with the signal that is connected to the checkup database being selected by the microcontroller. After that, the microcontroller will look for an a.wav file with a similar name on the SD card and play it. This information will be shown on an LCD screen and retransmitted through the speakers connected at the end of the frames.

IV. FUTURE OF THE DEVICE IN THE U.S

The future of a smart device like the one I proposed is positive, as more researchers look for innovative methods to assist people with moderate to severe hearing loss in enhancing one-on-one communication. The dawning of the era of hearables is rapidly approaching. Even though devices now come preloaded with smart assistants that go well beyond the convenience of voice control, understanding how deaf users have used smart assistants and the difficulties they encounter is becoming more essential as the technology becomes more widely available [16]. With advancements in hearing and ear-based technology such as earphones, headsets, cochlear implants, and a variety of other tools that monitor different health indicators through the ears – dubbed "hearables" – a new era of hearing-related therapies is on the horizon. Most of these gadgets perform a variety of tasks, may be used for diagnostic and therapeutic purposes, and are available in a variety of designs, colors, and levels of usability. A wide range of auditory care technologies is now available on the market, including hearing devices that allow the deaf and partially deaf to be assisted [16,17]. Over the past 10 years, they have undergone a complete transformation. These have advanced from being simple hearing aids to being multipurpose medical devices, and they will continue to develop in the future. Modern versions of these devices have a connection to the Internet, are capable of scanning the whole sound environment 100 times per second, are compatible with iPhones, and are capable of reducing the noise before providing it. As per industry analysts, Bluetooth technology will become a common feature in cochlear implants shortly, and this is especially true now that Apple has trademarked specialized Bluetooth technology for hearing devices that will link to the various operating system platform [17].

The most accurate way to describe the overall trend that is taking place here is to say that these newest computers on the market are transitioning from being a simple healthcare instrument to being a sophisticated digital aide, able to carry out tasks that go well beyond respond and recover hearing problems. In the future, they will be able to alter people's perceptions of their surroundings and provide services that were previously beyond of reach. I hope that my device will be recognized as one of the top innovations that will have a significant impact on the deaf population. As a result, in the future, individuals who use hearing aids will be transformed into sci-fi futuristic features. For example, TV ears are a simple invention that is assisting individuals with hearing loss in hearing the television correctly with no need to increase the volume of the television. Another piece of technology introduced by Starkey Hearing Technologies in 2019 is capable of detecting falls as well as measuring physical activity [17]. The firm is also currently developing sophisticated sensors, such as a heart rate sensor, which will be available soon. When it comes to fitness and health, hearing aids are now being advanced, resulting in their being the new wristband, figuratively speaking.

V. ECONOMIC BENEFITS FOR THE UNITED STATES

My proposed device will be economically beneficial to the United States by helping more people get into the workforce that could otherwise be a challenge without a communication device. It's important to note that although AI development is a key element, voice command is also important. More sophisticated machine learning will have an impact on a variety of different job fields. Human resource departments will almost certainly be controlled by artificial intelligence, and many services will be performed by voice assistants [17,18]. The banking industry is one area that has the potential to be significantly impacted by artificial intelligence and voice command. Machine learning may be used to automate more straightforward operations such as trading, cold calling, and other related operations [18,19]. For those who utilize this technology, it has the potential to decrease marginalization and enhance independence while also providing them with educational, financial, and social possibilities. This breakthrough will pave the way for new technological trends, particularly in the areas of applications, integration in the medical sector, education, robotics, and other disciplines [19]. This will be a component of the integration of artificial intelligence with economic growth in general.

VI. CONCLUSION

This research looked at developing an AI voice-based smart Device that can assist disabled deaf people to understand and respond to their body language. This study looked at the development of an artificial intelligence voice-based smart device that can help deaf individuals with disabilities in understanding and responding to their body language. It's no secret that AI is playing an increasingly significant role in the development of new technologies, including communication aids for the deaf population. The device that I came up with is mounted on optical classes' frames. Some of its important components include the Flex sensors, LCD module, microcontroller, SD card memory, hearing phones, etc. It works by reading and turning body language into a voice that a user can hear on their hearing aids attached near the end of the frames. According to the reviewed literature, the application of voice assistants improves the quality of life without the assistance of some artificial means. Individuals who have impairments such as limited hearing, vision, or portability can benefit from voice commands since it will make their lives easier. Additionally, voice command will assist to simplify the lives of the ordinary individual by making tasks such as housework and shopping much simpler to do. The presence and availability of various safety mechanisms for intelligent tools on the market provide residents with the capacity to defend themselves and keep track of what is going on around them, thus improving their sense of control and safety altogether. Assistive communication and alternative/augmentative communications will continue to develop technologically in the coming years. The aim is to take advantage of emerging technology and use them in ways that will enhance communication between individuals who are profoundly deaf. Currently, the issue is to persuade the industry to open or extend the capability of assistive communications and alternative/augmentative communications equipment over their present capabilities. The development of smart applications, hearing aids, and cochlear implants, as well as many other add-ons that transform cell devices into otoscopes, are already underway, enabling people to achieve special properties. But with my proposed technology, some developments could address the hearing challenges forever.

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