**Application to aid hearing and speech impaired people.**

Akshatha, Steve, Anupriya, Rakshith

Shri Madhwa Vadiraja Institute of Technology and Management, Bantakal, Udupi, India.

***Abstract:***  **One of the most priceless gifts to a natural being is the capability of vision, hear, express and react corresponding to the situations. Interaction between deaf-dumb and ordinary being is an inspiring mission. The hearing-impaired and the mute society depends mainly on the hand gestures known as the Sign Language for communication. The Sign Language Identification is one of the revolutions for serving the specially-abled society. The exploration of identifying sign gestures is successful, but involve an exclusive charge to be commercialized. For the Sign Language Identification System to be used widely, the data acquisition process varies largely depending on the cost of the system, the methods used, limitations etc. The course of learning, recognizing the signs and interacting via the ISL can be simplified by the proposed system that converts speech to the sequence of sign language symbols. Speech processing embraces Speech Recognition, the learning of identifying the vocabularies being vocalized, irrespective of who the orator is. The proposed system practices template-based detection as the key tactic where the Voice to Sign (V2S) system initially requires to be skilled with dialogue plan based on the predefined database of signs. It correspondingly translates speech to text via the dictation recognizer of the Unity 3D tool, processes the text and maps the phrases to animations that will assist to convey the desired message. By means of the proposed system trainers will be able to teach the sign language effortlessly without explicit training.**

1. **INTRODUCTION**

The Indian Sign Language (ISL) is one of the most important modes to exchange the ideas for dumb and deaf individuals in India. Each country has it's communicating sign language which is a finely structured code of gesture, with a unique meaning mapped to each one. The ISL uses manual communication or body language or signs to convey thoughts and ideas. Communicating using the ISL, on the other hand, requires sophisticated training and practice. On the other hand, locating skilled and qualified teachers for their daily affairs is an extremely tough chore and also overpriced.

The latest statistics issued by the World Health Organization (WHO) demonstrates that for individuals aged above 50 years, the audible range gradually increases over the time all over the world. It is probable that above 900 million public throughout the globe will experience loss of hearing ability by 2050 [1]. Nearly 466 million individuals universally have difficulty to perceive sound and the count of youngsters’ ranges in 34 million out of these. The 'Deaf' community comprises of individuals of very diminutive or no hearing ability. Communication takes place through hand gestures. All around the world, different communities use variant sign languages in distinctive fragments of the globe. Put side by side to verbal lingos they are very fewer in number [2].

There has been an exponential increase in the recognition and development of the ways to interact with the specially-abled. Those with physical frailties such as deafness, loss of sight, or deaf-blindness depend on their working senses to be in contact and have access to the world. The initial lingo the deaf children absorb is the sign language as their primary language. But only 386 schools for deaf and dumb are established in India as of 2017. They have an issue to express themselves or understand the printed text, numbers and also issue while making an image of abstract thought in mind and are unable to access the information which the normal people do very easily like television content multimedia on web and individual public speeches. They desire to retrieve facts in the mode of hand gestures on the Internet instead of written subject but incredibly limited sites propose gist in sign language in the form of cinematic clips and can be retrieved by interpreting the script. Producing the material available on the Internet by means of a filmed methodology is expensive [3]. This demand for the need for a platform that acts as the intermediate between the hearing-impaired person and normal person even if he is not acquainted with the use of the internet or browser. Equipping dumb and deaf with qualified and trained teachers can be a challenging task mainly from a financial point of view.

The existing sign language applications are constrained to text inputs and cannot very clearly handle combined phrases or SOV (Subject object verb) pattern. These issues are addressed with the assistance of Natural Language Processing to break down the script into slighter comprehensible fragments. All the animations of Avatar will be created. The project's UI part includes a dictation recognizer. Text pre-processing part includes removing stop words, lemmatization, handling synonyms and transforming the given sentence into SOV form (since ISL sentences have to be in SOV form mandatorily).

The proposed system converts speech by the conveyer to the sequence of sign language symbols for the dumb and deaf to communicate. It also converts speech to text, processes the text and maps the phrases to animations that will help convey the desired message using Avatars. There have been several considerable research activities in developing a system for the generation and automation of sign language. This automated system takes either text or speech input to generate sign language as output.

About 4million deaf and about 10million find difficulty in hearing are present in India as reported by the All Indian Federation of the Deaf (AIFD). ISL is a way of interaction for further 1 million deaf grownups and about 0.5 million deaf. The Sign-Language-Recognition (SLR) intents to equip algorithms and approaches to appropriately recognize an arrangement of shaped signs and deliver its gist in manuscript or dialogue. The two key classes of the SLR scheme: vision-based and sensor-based. Vision-based systems exploits pictures and films of symbols developed from cameras. Likewise, sensor-based systems need the custom of wearable strategies armed with sensors to abstract the hand gestures and wave of the signs [4]. The projected scheme makes use of the Vision-based system to capture the gestures acted by deaf and dumb.

The SL can be staged via hand-gesture either by one hand branded as Isolated sign language or two hands recognized as continuous. sign language. The sign language comprises a solo gesture consuming only a word whereas continuous ISL is an arrangement of signs that causes an expressive verdict. The proposed system operates on a continuous ISL sign recognition procedure using ISL. Continuous ISL signs are typically crafted of two-handed besides it is a blend of active as well as still gestures. Hence, the issues to identify signs in the actual setting increases [5]. The continuous SL recognition focuses on studying unsegmented signs of audio-visual recordings and aimed at dispensation continuous motion films in actual organizations. Lately, deep convolutional neural networks include an incredible influence on associated errands on films. For example, homo sapiens motion recognition, gesticulation recognition, and Recurrent Neural Networks (RNNs) revealed the signiﬁcant consequence on studying the time-based needs in symbol noticing [6]. In other words, neural networks are limited to acquiring bit-wise depictions. The Hidden-Markov-Models (HMMs) are intended for categorized learning. Though, the bit-wise classification is not noise free to exercise the deep-neural-networks, besides HMM may well be tricky to gather the intricate active dissimilarities, in view of the partial illustration skills.

The idea can not only be used by teachers, but also by any person for that matter, who wants to communicate a given message through sign language without having any training for the same. This idea can be extended to multiple languages also, in which case languages other than English can also be used. The proposed system can recognize hand gestures accurately with a single normal webcam and convert it into text and voice messages. The objective of this scheme is to distinguish the signs by means of peak precision in addition to the minimum amount period and render the letters of ISL hooked on to the equivalent manuscript and speech in a vision-based fashion or commonly known as Avatars.

1. **LITERATURE REVIEW**

Ruxandra Tapu *et al.,* [1] projected a scheme that utilizes equally deep convolutional neural networks and computer vision algorithms carefully devised to sense as well as identify the characteristics of the dynamic orator in the film. The drawback appears as soon as numerous individuals’ stage in the identical act and occupied in a discussion, the issue is to classify the individual who is presently voicing. An additional unclear condition points the event in which the expression of the orator is undetectable. DEEPHEAR permits the audiences at ease stick to the film information at the same time as the accompanying descriptions by locating the captions that causes to classify the involved orator. The DEEPHEAR skeleton equally utilizes deep Convolutional Neural Networks known as CNN and computer vision procedures to accomplish the innumerable phases essential, together with detection of face, recognition and tracking, film time-based breakdown, involved orator recognition and identification, script discovery and description locating. The scheme is unqualified of being employed in circumstance of absent appearance of a person in the cinematography. The outspread of the construction to deal with voice-to-script library for films in which the caption write down is inaccessible in early stage.

Richard E. Ladner [2] reviewed modules of message passing equipment for audible range enrichment machinery. Primary automated supports for hearing only improved the hearing capabilities to a little extend along with non-linear disturbance cancellation subjected with the help of some machinery tools. The assistance tools could be high-priced, smart-aids estimate in a couple of thousand-dollars also cochlear transplant operation costs more than the reach of a common man. But in both the cases of automated support tools and cochlear transplants, there is a requirement of persistent safeguarding, chiefly replacement of battery has to be done regularly. For the reason of expense, a mere fraction of individuals may perhaps afford these automated hearing tools or manage to have a cochlear implant. Emerging with minimal budget automated tools is the key practical test. The two elementary modes using which the deaf community can interact: script and sign-language.  Each part of the world has their own distinct ways to the sign language on the contrary there is no prevailing written-form that is accepted by all.

The paper by Jestin Joy *et al.,* [3] examined the Sign-Quiz that customs Deep-Neural-Networks (DNN). Sign-Quiz application will be capable of effortlessly be exercised deaf and also a normal person besides it is economical, constructed to be used on website, hand gestures sign education presentation for ISL applying programmed identification of sign language procedure by means of DNN. Fingerspelling is represented via alphabets of a scripting scheme and digit schemes. Its performances as an intermediate linking the SL and spoken lingo. The ISL is capable of signifying English letters A to Z with ﬁnger-spelling. It characterizes texts that do not have any hand gesture corresponding to it or to manipulate an expression or allotted in schooling of the SL. The operator has the privilege to hand-pick letters. For the respective letter, pictures and films are presented. But absorbing hand gestures is extremely tricky to be used by a learner lacking the assistant of proficient SL expert. Sign-Quiz assessments examined volunteers who participated in it, the results showed maximum volunteers were enthusiasts of tools-based presentations.

Suhail Muhammad Kamal *et al.,* [4] presents a methodological summary of the methods in scheming a Chinese-Sign-Language-Recognition (CSLR) structure. The Sign-Language-Recognition (SLR) schemes utilized are Finger-Spelling in circumstances in which different vocabulary, person's name, location, terms without recognized hand gestures are enacted by hand-motions. The gesticulation identification examines an arrangement of pictures or motion made by hand activities via gloves embedded with sensors or just a webcam. The Chinese-Sign-Language-Recognition (CSLR) employs Neural Network and Hidden-Markov-Models (HMM). The gloves embedded with sensors testified prominent precision but typically operated on isolated expression identification. Mining of only the applicable descriptions from statistics obtained via the sensor-tools may not be generally exploited for the reason of its high-priced, although it is easy to collect the data from the sensors. Moreover, the data-set cause problems that is aimed at attaining an extraordinary routine the SLR scheme. The list of datasets available are publicly available dataset and also does not contain much information which can allow to improve and compare various state-of-the art techniques; incorporating facial expressions that convey extra meaning in a sign language sentence as the state of-the-art German sign language dataset.

Runpeng Cui *et al.,* [6] SIGN language (SL) is commonly known as the primary language of deaf people, and usually collected or broadcast in the form of video. The SL is often considered as the most grammatically structured gestural communications. This nature makes SL recognition an ideal research field for developing methods to address problems such as human motion analysis, human-computer interaction (HCI) and user interface design, and makes it receive great attention in multimedia and computer vision. This work develops a continuous sign language (SL) recognition framework with deep neural networks, which directly transcribes videos of SL sentences to sequences of ordered gloss labels. Previous methods dealing with continuous SL recognition usually employ Hidden Markov Models (HMM) with limited capacity to capture the temporal information. SL recognition concerns more about learning unsegmented gestures of long-term video streams, and is more suitable for processing continuous gestural videos in real-world systems. Its training also does not require an expensive annotation on temporal boundary for each gesture. Recognizing SL indicates simultaneous analysis and integration of gestural movements and appearance features, as well as disparate body parts, and therefore probably using a multimodal approach. The focus is on the problem of continuous SL recognition on videos, where learning the spatiotemporal representations as well as their temporal matching for the labels is crucial.

The paper by Mu-Chun Su *et al,.* [7] discussed that as a result of congenital malfunction, diseases or accidents, deaf-blind people are unable to interact with the external world in the same way as non-handicapped people usually do. The tactile channel is the only communication channel available for deaf-blind people. Although deaf-blindness is a low incidence handicap, it presents many intriguing and difficult challenges to rehabilitation engineers. The development of a portable communication aid, which allows deaf-blind people to communicate with others without the help of an assistant. The system comprises two major units: one for deaf-blind people and the other for sighted people. A deaf-blind person can send messages by typing on a Braille terminal and the messages will be converted to Mandarin phonetic symbols, which are then displayed on an LCD display to be read by a sighted partner. Then the sighted partner can send messages back by typing on a simple keyboard and the messages will be displayed on a Braille display to be ‘read’ by the blind-deaf person. The aid has been designed to be effective, reliable and inexpensive. Some experimental results are reported to demonstrate the applicability of the aid. A PC-based telephone communication system designed for deaf-blind people was proposed. Recently, Damper and Evans developed an electronic system to alert a deafblind man to the occurrence of a variety of household sounds, such as a doorbell, telephone or a smoke alarm.

The paper by B. G. Lee *et al.,* [8] proposed that the Sign language plays a vital role for deaf and mute people to communicate among themselves or with normal people in a non-verbal manner. Gestures are the primary method to convey messages, which are usually conducted in a three-dimensional space, known as a signing space, through an integration of manual and non-manual signals. Manual signals commonly correspond to hand motions and hand posturing, whereas non-manual signals correspond to an external appearance such as mouth movements, facial expressions and body orientation. In this paper, a smart sign language interpretation system using a wearable hand device is proposed to meet this purpose. This wearable system utilizes five flex-sensors, two pressure sensors, and a three-axis inertial motion sensor to distinguish the characters in the American Sign Language alphabet. The entire system mainly consists of three modules: a wearable device with a sensor module and a processing module, and a display unit mobile application module. Sensor data are collected and analysed using a built-in embedded support vector machine classifier. Experiment results indicate that a true sign language recognition accuracy rate of 65.7% can be achieved on average in the first version without pressure sensors. A second version of the proposed wearable system with the fusion of pressure sensors on the middle finger increased the recognition accuracy rate dramatically to 98.2%.

In paper [9] by Oi Mean Foong, *et al.,* proposed that speech processing which includes Speech Recognition is the study of recognizing the words being spoken, regardless of who the speaker is. In this use template-based recognition is the main approach in which the Voice to Sign (V2S) system first needs to be trained with speech pattern based on some generic spectral parameter set. These spectral parameter set will then be stored as template in a database. The system will perform the recognition process through matching the parameter set of the input speech with the stored templates to finally display the sign language in video format. Empirical results show that the system has 80.3% recognition rate. The interface of this project was designed to have few buttons and a display panel for simplicity purposes. By clicking on the “V2S” button on the screen the user is allowed to input raw voice i.e. recording of spoken voice into the system. There is a display panel to display the appropriate video output (Sign Language) which is the relevant translation of the spoken word. Natural Language to SL translation is the main scope of this research. The fundamental idea of this system is to translate the human voice to SL. The system will match the captured voice with the pre-stored SL videos in the database to display the appropriate sign/gesture thus provide an alternative interactive way of communication between a normal person and a hearing-impaired person. The prototype allows translation of spoken English to SL in Malaysian context. The system accuracy depends on how much system training was conducted. With sufficient training, it will be able to recognize all the trained commands or words and execute the corresponding translation.

The paper [10] by Suharjitoa, *et al.,* proposed deafness is a disability that impair their hearing and make them unable to hear, while mute is a disability that impair their speaking and make them unable to speak. Both are only disabled at their hearing and/or speaking, therefore can still do much other things. The only thing that separate them and the normal people is communication. If there is a way for normal people and deaf-mute people to communicate, the deaf-mute people can easily live like a normal person. And the only way for them to communicate is through sign language. This paper aims to discuss about the Sign Language Recognition form application point of view and the device used in getting the data, data acquisition, such as data from early researches or self-made data, the recognition method that are recently used by researchers, and the output of previous researches. It starts from the data acquisition methods. The data acquisition method varies because of the cost needed for a good device, but cheap method is needed for the Sign Language Recognition System to be commercialized. The methods used in developing Sign Language Recognition are also varied between researchers. Each method has its own strength compare to other methods and researchers are still using different methods in developing their own Sign Language Recognition.

The paper proposed by Anish Kumar *et al,.*[11] discusses about the digital era with advancement in information and communication technology. The deaf and dumb people are not involved with the social world because of their disabilities. Unintentionally, they are treated in an unusual manner by the rest of the society. Sign language is a communication skill that is used to convey a meaning of a speaker’s thought using signs gestures. It is a well-structured code gesture; each gesture has a meaning assigned to it. The gesture is a non-verbal communication which includes the movement of the1 hand, head and other body1parts. We have designed the prototype model for blind, deaf and dumb people into a single compact device. The advantage of this device is that it can be easily portable due to its less weight and size. This paper fulfils the hand gesture recognition process with some limitations as both the hands cannot be used in this technique because the result is not efficient. It uses Raspberry pi, Logitech camera, OpenCV Python, Espeak, Virtual Network Computing (VNC) etc to make this possible to work efficiently.

This article by Chijioke [12] draws on some of the existing literature on the politics of identity and representation as related to minority group formation. It applies this to construction of Deaf identity from a cultural and linguistic perspective and contrasts this with dominant constructions of Deaf people as disabled. The article concludes by recognizing the importance of diversity in identity formation, while simultaneously calling for an appreciation of the need to incorporate this diversity within wider theorizing, focused on commonality and cohesion in identity as a source of collective expression and political mobilization. The first step is to make clear the distinctions employed in this article. The distinctions I make are between deaf people who have lived most of their life as hearing people and have subsequently lost their hearing but still communicate through speech. There are also deaf individuals who have sought to communicate orally because of the education choices that have been made on their behalf.

1. **PROPOSED SYSTEM**

The alphabets, numbers and hand gestures used in the Indian Sign Language varies from that of the other country’s sign language. Each region inherits its own hand gestures for each alphabets and numbers to form words and sentences. The hand gestures for alphabets used in Indian Sign Language is given in Fig. 1.

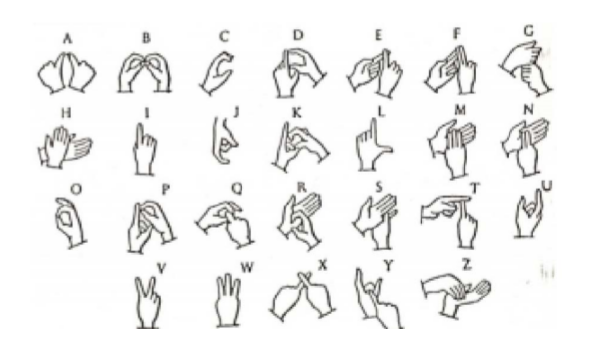
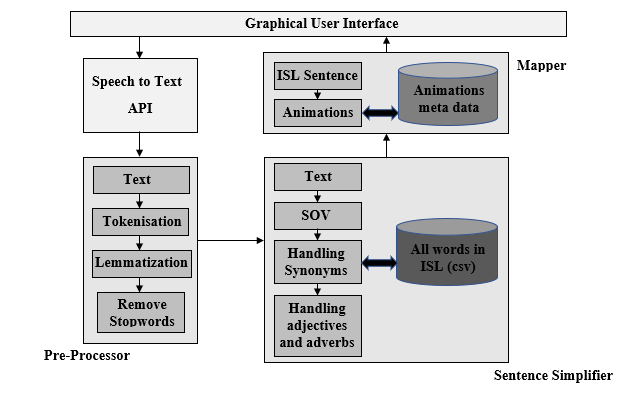


Figure 1: The Indian Sign Language [13].

The following steps are considered in the architectural design of the application:

1. **Speech to text conversion:** Since the basic idea of the project is to convey spoken message to ISL animation, the input in the form of speech is recorded and converted to text [10]. The input can also be in the form of direct text.
2. **Text pre-processing:** The input obtained cannot be used directly for animations because spoken languages do not adhere to the grammar rules of the ISL. Hence the input text has to converted to its equivalent ISL form. There are certain rules that are to be followed to convey a message in ISL. Words are always used in their root form and in their present tense. Undefined signs are split and shown as alphabets. The most significant rule is that every ISL sentence has to be in SOV (subject-object verb) notation. To achieve this, the text is processed using NLP functionalities such as finding root words, lemmatization, removing stop words and identifying the parts of speech (POS). The final sentence will be in the ISL format.
3. **Text to animation mapping:** The words in the processed input have to be mapped to their respective animations. In case the animation for that word is not present, its synonym is mapped. If the synonym does not exist too, it is split according to its alphabets.
4. **Animation:** The output is conveyed using an Avatar. These animations are combined to communicate the ISL sentence. Hence a given sentence is converted into its ISL form.

The application architecture diagram is a series of step-by-step as depicted in Fig.2.

Figure 2: The Architecture Design

Below is the sample output.

* A story is dictated using the microphone and it appears as text on the screen as follows:

One day, a clever man sold his well to a farmer. The next day, when the farmer went to the well to fetch some water, the man refused him telling that he only sold the well and not its water. The farmer, with a sad heart, went to Akbar’s court. Birbal was told to solve the complaint. The following day, the man and the farmer were called to the court. The clever man told – he sold his well, not the water in it. On learning this, Birbal said, “My friend, in that condition, you either remove your water from the well or pay tax for your water because it is the farmer’s well”. The man understood his mistake and asked for forgiveness.

* After text processing, the output story is in the form of ISL as follows:

one day clever man his pond to farmer sell next day farmer to pond to some water go bring when man him that he only pond reject tell sell n o t it water farmer with sad heart to a k b a r court go b i r b a l tell to complaint solve follow day man farmer call to court clever man he his pond tell sell n o t water in it on this learn b i r b a l order my friend in that condition you e i t h e r your water from pond o r tax f o r your water b e c a u s e it farmer pond remove pay man his mistake understand f o r f o r g i v e n e s s ask

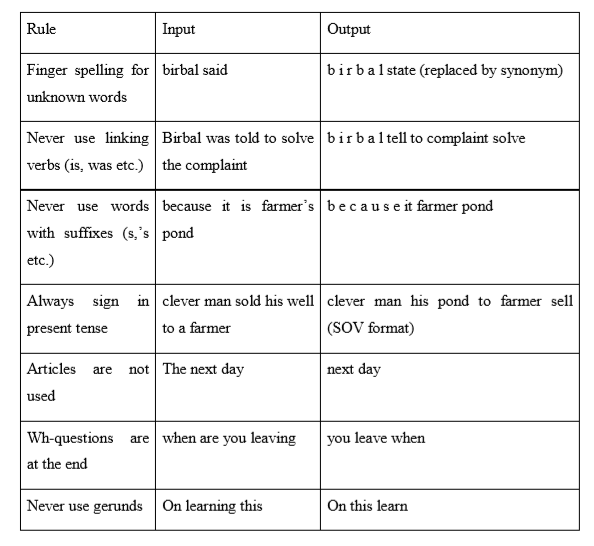


Figure 3: The ISL Rules and Regulations

The existing live SLR approaches suffer from a few downsides of complexity in identifying composite hand gesticulations, minimal distinguishing precision for many active SLR, also the probable complications in the bulkier cinematic chain of information guiding. The SL put together a sequence of movements that take in swift gestures in addition to alike features. Thus, the dynamic SLR is problematic to transact in addition to the density and huge dissimilarities of terminology database in hand-gestures. Also, it possibly will misinterpret a variety of alternatives with one another. The dynamic SLR encounters difficulties in production besides the intricacy of gesture behaviors of ﬁnger movement of the wide-ranging frame environment. The mining of the utmost judicious characteristics from pictures and films is another added problem. Further, picking a suitable classiﬁer is a desperate feature for influencing exact perception outcomes. Two of the numerous modes to resolve the setback with dynamic SLR are - the first one is the process grounded on hand signs and movement curve of hand-gesticulations; the next one is the technique built on a cinematic arrangement of respective SL [3].

1. **OUTCOME**

It aims to eliminate the explicit training which teachers have to undergo to teach in a Deaf and Dumb School. Using this project any person can teach the students in the deaf and dumb school. This project will ensure that deaf and dumb school students can get access to the majority of the learning materials and resources which were otherwise unavailable to them due to language barriers.

1. **INDUSTRY APPLICATIONS**

The end product is an open-source desktop application that is platform-independent. The UI is user-friendly which consists of an avatar, an input field, a button to record the voice in case of audio input, and a submit button. The ISL equivalent of the text along with the animation being played is displayed simultaneously after the input is processed. There is no considerable delay to display the animation through an avatar on submitting the text in the input field. The animations are clear with smooth transitions.

This application will simplify the job of teaching the mute community. It is quite hard to learn and master the Sign Language, as it is time-consuming. This application eliminates the requirement of knowing the ISL beforehand. This product can not only be used by teachers, but also by any person, who wants to convey a message through sign language without having any training for the same.

Since ages, very little importance has been given to deaf and dumb. This can be noticed in the epics of this country. We cannot find many characters being deaf and dumb in any of the greatest epics of this country. Although they have the most perceiving sensory organ of the human body, which is the eye, using it to their fullest advantage has not helped them in achieving great feats [11]. The main reason is due to lack of resources and awareness among the people, that’s why it’s difficult to find the deaf and dumb achievers in this country. So, this project will help the people with such disabilities to learn on level ground along with the rest of the world.

There is no professional technical solution to teach the deaf and dumb until today. Few of the mobile applications which exist now merely convert each word into its respective sign without following ISL grammar. Also, there are hardly any applications that take in voice input also. Some of the existing applications are not open source.

This application follows all the ISL grammar rules and regulations. Thus, this project can be of great use to the deaf and dumb and is a humble attempt to give something back to society.

1. **CONCLUSION**

The prevailing sign language applications are constrained to text inputs and cannot handle combined phrases or SOV (Subject object verb) pattern. Many of them are in the form of mobile applications that do not consider audio input. These matters are addressed by means of the semantics of Natural Language Processing to break down the script into slighter comprehensible fragments, and through dictation recognizer which takes in speech as input through a microphone.

The idea can not only be used by teachers, but also by any person for that matter, who wants to communicate a given message through sign language without having any training for the same. This idea can be extended to multiple languages also, in which case languages other than English can also be used.

Motion identification empowers machines to be familiar with humanoid activities as well as perform identically to a translator among machines and a being. The ability of an individual to interrelate logically employing the machines may be deprived of bodily interaction at all [1].

Linguistic is entertained as a crucial basis of interaction between the human society. Signs can stem from the movement of a body part, usually initiated as the action of expressions made by face and hands. An extent of computer vision is Body Language Identification, it takes into account understanding the signs via a diverse set of rules. In attendance is a shared delusion regarding the SL that it is global furthermore the society of unresponsive fitting to whichever chunk of the globe uses the identical lingo. [2] However, the aforementioned is known that numerous gesture lingos use the resemblances of one another. The precise count of the prevailing sign-languages is not known, nevertheless, the 2013 publication of Ethnologies’ rolls them 137.

**REFERENCES**

[1] Ruxandra Tapu, Bogdan Mocanu and Titus Zaharia, “DEEP-HEAR: A Multimodal Subtitle Positioning System Dedicated to Deaf and Hearing-Impaired People” IEEEAccess, vol. 7, 2019.

[2] Richard E. Ladner, “Communication Technologies for People With Sensory Disabilities”, IEEE, vol. 100, 2012.

[3] Jestin Joy, Kannan Balakrishnani and Sreeraj “SignQuiz: A Quiz Based Tool for Learning Fingerspelled Signs in Indian Sign Language Using ASLR”, IEEEAccess, vol. 7, 2019.

[4] Suhail Muhammad Kama, Yidong Chen, Shaozi Li and Xiaodong Shi and Jiangbin Zheng, “Technical Approaches to Chinese Sign Language Processing: A Review”,IEEEAccess, vol. 7, 2019.

[5] Formation Kumud Tripathi, Neha Baranwal and G. C. Nandi, “Continuous Indian SignLanguage Gesture Recognition and Sentence”, Eleventh International Multi- Conferece on Information Processing (IMCIP), Elsevier, 2015.

[6] Runpeng Cui, Hu Liu, and Changshui Zhang, “A Deep Neural Framework for Continuous Sign Language Recognition by Iterative Training”, IEEE, 2018.

[7] Mu-Chun Su, Chia-Yl Chen, Shi-Yong Su, Chien-Hsing Chow, Hsiang-Feng Hsiu and Yu-Chine Wang, “Portable communication aid for deaf-blind people”, Feb. 2001.

[8] B. G. Lee, Member, IEEE, and S. M. Lee, “Smart Wearable Hand Device for Sign Language Interpretation System with Sensors Fusion”, IEEE, 2017.

[9] Oi Mean Foong, Tang Jung Low, and Wai Wan La ”V2S: Voice to Sign Language Translation System for Malaysian Deaf People”, ResearchGate, Nov. 2009.

[10] Suharjitoa, Ricky Andersonb, Fanny Wiryanab, Meita Chandra Ariestab, Gede Kusumaa, “Sign Language Recognition Application Systems for Deaf-Mute People: A Review Based on Input-Process-Output”, 2nd International Conference on Computer Science and Computational Intelligence 2017, Bali, Indonesia, Elsevier, October 2017.

[11] Anish Kumar, Rakesh Raushan, Saurabh Aditya, Vishal Kumar Jaiswal, Mrs. Divyashree Y.V, “An Innovative Communication System For Deaf, Dumb and Blind People”, International Journal for Research in Applied Science & Engineering Technology (IJRASET), Volume 5, Issue VI, June 2017.

[12] Chijioke Obasi, “Seeing the Deaf in ‘Deafness’ “,Journal of Deaf Studies and Deaf .Education 13:4 Fall 2008

[13] B. Lakshmi, “Assistive SIGN LANGUAGE Converter for DEAF AND DUMB“, International Conference on Internet of Things (iThings) and IEEE Green Computing and Communications (GreenCom) and IEEE Cyber, Physical and Social Computing (CPSCom) and IEEE Smart Data (SmartData), 2019.