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Deaf Mute Communication Interpreter- A Review

Sunitha K. A[1], Anitha Saraswathi.P[2], Aarthi.M[3], Jayapriya. K[4], Lingam Sunny[5]
[1,2] Assistant Professor, [3,4,5]Students
Department of Electronics and Instrumentation Engineering
SRM University, Kattankulathur, Chennai-603203, India.
[1]sunitha.k@ktr.srmuniv.ac.in,[3]aarthi.murali95@gmail.com,[4]jayapriyakumaar@gmail.com,
[5]sunnylingam09@gmail.com

Abstract
Communication between the deaf and non-deaf has always been a very cumbersome task. This paper aims to cover the various prevailing methods of deaf-mute communication interpreter system. The two broad classification of the communication methodologies used by the deaf –mute people are - Wearable Communication Device and Online Learning System. Under Wearable communication method, there are Glove based system, Keypad method and Handicom Touch-screen. All the above mentioned three sub-divided methods make use of various sensors, accelerometer, a suitable micro-controller, a text to speech conversion module, a keypad and a touch-screen. The need for an external device to interpret the message between a deaf –mute and non-deaf-mute people can be overcome by the second method i.e online learning system. The Online Learning System has different methods under it, five of which are explained in this paper. The five sub-divided methods are- SLIM module, TESSA, Wi-See Technology, SWI_PELE System and Web-Sign Technology. The working of the individual components used and the operation of the whole system for the communication purpose has been explained in detail in this paper.

Keywords: Communication Interpreter, Sign Language, Deaf-Mute.

Introduction

Deaf and mute are facing the communication problem with everyone they interact and the key solution is the Sign language. It is nonverbal form of language that uses gestures to convey thoughts and gesture is a particular movement of hands with a specific shape made out of them [1]. In the last several years, there has been an increased interest among researchers in the field of sign language recognition for introducing means of interaction among the deaf as well as among the deaf and non-deaf. Finding an expert interpreter for the day to day activities is a difficult task and is also unaffordable. Since communication is the fundamental aspect of human survival, various measures have been taken to technically improve the ease of communication for the deaf. There is no common sign language, it varies for each part of the world and even among the same country. Sign language, finger spelling, paper and pen method comes in handy in some situations but not in all. Hence for the ease of communication between the deaf and non-deaf people various electronic and digital methods have been employed. The methods can be broadly classified under the following two categories-

Wearable Communication Device

Online Learning System

Under Wearable Communication Device, the first method is the glove based systems, which was invented 30 years ago and researches are still continuing to study on it [2]. The glove system acts as an interpreter. This is a sensor based system that converts the input gestures made by the deaf in sign language into voice and text message.

E-learning environment is one of the most used techniques for educational purpose of Deaf and hard hearing students.Researches on the usage of the e-learning environment for hearing impaired students started from the year 2005 and still it is going on to make it more effective [3]. With the development of technologies various different methodologies and devices have been introduced for the deaf-mute communication. Google has come up with a new wristband that could measure the wearer's muscle activity, recognizing sign language symbols and speaking them through an Android device [4]. It could convert the gesture into a voice form. Though this Google wristband is only theoretically approved and not experimentally proved. Motion Savvy introduced a two-way communication device called UNI [5]. It is a mobile device that recognizes the hand gestures and converts them into a voice message. It can convert sign to speech and speech to text message. There have been numerous deaf/hearing android apps coming up that have also contributed a little in the ease of communication for the deaf.

Recently TOSHIBA is trying to make a human-like sign language robot that will act as an interpreter for deaf and mute people [6]. In 2013 three other mobile devices were created to facilitate communication between the deaf and hard hearing impaired people. The first is called Visual Sound Station. It captures indoors sounds and portrays them in visual form. The device has two micro-electromechanical microphones that distinguish specific sounds such as fire alarms, doorbells, a telephone ringing or a baby crying. These sounds are represented in width and visualized in direction, giving the hearing-impaired person a depiction of what is happening in that particular realm of sound [7]. It is estimated that only 10% of the deaf have access to communication tools because of the high cost. The challenge, at present, is to overcome this gap by developing technological tools that respond to the real needs of the deaf and are easily and readily available to them, their families, schools and institutions [7].

Discussion
Wearable Communication Devices
Glove Based System

The interpreter here makes use of a glove based technique comprising of flex sensor, tactile sensors and accelerometer [8]. The controller that is used here is ARDUINO which is fed with pre stored data for various gestures used in sign language. Depending on the gesture that is made by the user the various sensors present in the glove will detect the gesture by producing a corresponding signal and checks if it matches with any of the pre fed inputs. A general block diagram for the glove based system is shown in figure1.

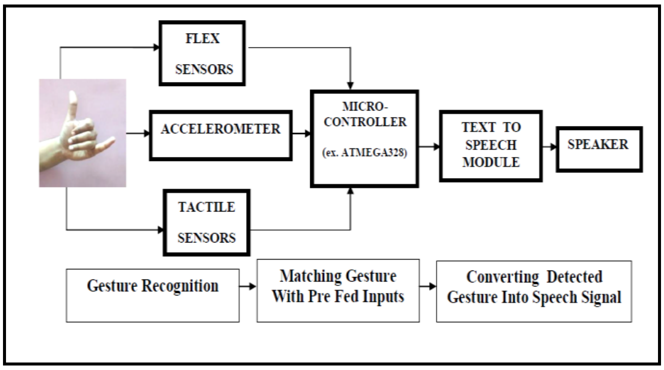

Figure 1: Glove Based System

Various Sensors Employed
Flex Sensors:

Five flex sensors are used here for each finger and it measures the angle of bending of fingers. These sensors are nothing but resistive carbon elements. When we bend our finger the sensor produces output resistance in relation with bending angle. The flex sensor's resistance changes based on the bending of the fingers. This change in resistance produces a corresponding output voltage from the voltage divider circuit. The resistor and flex forms a voltage divider which divides the input voltage by a ratio determined by the variable and fixed resistors [9].

The various other sensors that measure the angle of bending are the curvature sensor that measures the bending at the finger joints. It is a thin, transparent elastomer film (poly-dimethylsiloxane, PDMS) embedded with a micro channel of conductive liquid (eutectic Gallium Indium, eGaIn) and a sensing element [10]. The film is wrapped around the fingers in the hand with the sensing element placed on top of the knuckle. Finger bending both stretches the elastomer and exerts pressure on the sensing element, leading to an enhanced change in the electrical resistance [10]. Angular displacement sensor based on strain gauge is another sensor that measures angular displacement. Flexing the fingers will cause the strain gauge to go under tension and a corresponding change in resistance would be produced in proportion to the bending of the fingers [11].

Optical fiber transducer is another such glove mounted sensor that measures the bending of the fingers. The device was also mounted in a fabric glove to the monitoring of flexion and abduction movements of index and thumb fingers [12]. Using fiber optics to measure bend requires a light source such as a light emitting diode and a photo detector [13]. The change in the angle of bending is co-related with the change in the light intensity due to the fiber micro bending loses. The bending can also be measured by the use of Hall Effect sensor. Hall Effect sensors, which detect magnetic fields, and can be configured as proximity sensors to provide a linear output proportional to distance from a magnetic source [13]. When the fingers bend, there would be a corresponding change in the magnetic field.

Tactile Sensors

Tactile sensors are used here as a push to make switch which is stimulated by mechanical interaction and is used for feeding in the inputs and controller reset [8]. These are interfaced with the digital pins of the controller that is used in this method and when pressed externally, a temporary electrical connection is made. Tactile sensors consist of two pins- one is grounded and the other pin has +5volts supply to it. They can be used to improve the accuracy of the alphabets and for the formation of the words.

Accelerometer

They are used for measuring the dynamic acceleration that is caused from sudden shock, vibrations and static acceleration for tilt sensing. Accelerometer has a signal conditioning circuit with a 1-pole low pass filter, temperature compensation, and 0g-detect which detects linear free fall and a g- select input for the selection of sensitivities. It is a small, low power device that produces signal conditioned analog output voltage proportional to the acceleration. ADXL335, MMA 7260 are some of the accelerometers that can be used which is to be interfaced with the controller.

Controller

The controller is the most important part of the glove based system as it is where the input data are fed from the input sensors and it is a platform from where the output is generated. It detects the hand postures made by the deaf. The various controllers that can be used are AT89c51 microcontroller which has 4 ports- 2 for the input and 2 for the output, ARDUINO with an inbuilt ATMEGA 328. ATMEGA328 has 32KB on-chip flash memory for storing codes of which 2KB used for boot loader also with a 2KB of SRAM and 1KB of EEPROM[8].The flash memory is where the program that is required for the operation of the system is stored. An additional serial port is incorporated which is required for sending the data in or from the ARDUINO. Another popularly used controller is the PIC16F877A microcontroller that has 40 pins in it out of which 33 are the input/output ports. This microcontroller has an ADC module that converts the analog inputs from the sensors into digital outputs.

Text To Speech Conversion Module

It is the translation module that converts the input gesture into a voice message. The module comprises of an encoder (TTS256) - synthesis (SpeakJet). TTS256 has 28 pin DIP and 8 bit microprocessor that has various letters programmed in it. The built-in algorithm allows real time translation of English ASCII characters to allophone addresses [8], which facilitates in the text to speech conversion with the help of SpeakJet.

TTS256 accepts serial gestural data which is translated into audio signal from the SpeakJet using five sine synthesis generators, which is then amplified and sent to the speaker.

Operation of Glove Based System

The glove that is developed in this system can be used by the deaf for the ease of their communication with the non-deaf people. The hand gestures made by the deaf through sign language will be recognized by the flex sensor and accelerometer placed on the glove. The sensors produce a corresponding voltage signal based on the bending of the signal. The sensors recognizes the gesture (alphabets and words) made by comparing it with the pre stored inputs. This is then sent to the controller which has two modes of operation. The first one is the training mode where the voltage sent from the flex sensor is stored in the EEPROM. The second is the operational mode where the data received from the recognized gesture is compared with the predefined values or from the look-up table and the matched gestures are then sent to the text to speech module. If there is no match, an error signal will be produced.

Keypad Method

Another method is by using a keypad where the input text is displayed on the LCD. When the user presses a key on the keypad, the controller detects the key that is pressed and compares it with the pre-stored inputs, where each key has a particular word stored for it in the microcontroller and the output is displayed on the LCD which can be viewed by the deaf. The controller which has an ADC incorporated in it converts the analog signal sent by the sensors into a digital signal. This signal is then sent to an audio amplifier where the audio signal is amplified and sent to the speaker which can be heard by a non- deaf person and this communication is established between a deaf and a non-deaf. A voltage regulator can also be used in the system which provides 5volts supply to the flex sensors, amplifier and the microcontroller. A voltage of 3.3V is applied to the accelerometer.

In this module, a 65k color touch screen with TFT display and a mp3 audio speaker is used. The input gesture made by the deaf can be applied to the color screen by swiping on the touch screen. Output is obtained from the audio speaker based on the input word or letter or numerical that is applied to the screen in the form of gesture by the deaf. The touch screen used in this method is a resistive one which is operated based on the application of the applied voltage on the resistive network of the touch screen and the change in resistance is thus measured at a particular point on the screen where a touch is made, that is where the input is given.

The ratio of the change in resistance will mark the location in which touch is made on the screen. When a touch or press is made on the screen two mechanisms will occur at the point of contact on the screen. The first mechanism is the mechanical bouncing. It occurs due to the vibration of the top layer of the touch panel when it is pressed [14]. The second mechanism is the electrical ringing that causes due to the parasitic capacitance between the top and bottom layer of the touch panel. These two mechanisms cause the voltage to oscillate and the voltage level will finally decay down to a stable dc level. This module also consists of an inbuilt GSM Technology which is used to send SMS to mobile phones. This is useful for long distance communication.

Handicom Using Touch Screen

Another hand held wearable device for the ease of communication between the deaf and non-deaf is using a hand held device that is a touch screen. A touch screen is an electronic visual display that the user can control through simple or multi-touch gestures by touching the screen with one or more fingers [14]. In this method, two types of module are used. First is the gesture to voice translation and the second is the speech to image translation module.

The module used in this method is the speech recognition process where the speech is converted into image for the deaf to understand the speech of the non-deaf person. The input voice is translated into an equivalent image and is displayed on the screen used. This method includes a LPC1313 ARM Cortex –M3 processor which has high performance and low cost. It has an inbuilt Nested Vectored Interrupt Controller, 32 KB on-chip flash programming memory, 8 KB SRAM, In-System Programming (ISP), In Programming (IAP) via on-chip boot, Serial Wire Debug and Serial Wire Trace port, current output driver (20mA) on one pin and current sink drivers (20mA) on two I2C Fast-mode Plus [14].

Three reduced power modes: Sleep, Deep-sleep, and Deep power-down are used here. A serial peripheral interface (SPI) is used which helps in the intercommunication between microcontrollers and peripheral chips [14]. The SPI buses- LCD, sensors, memories, ADC, RTC are used here where the transmitting and receiving signal is guided by clock signal which is generated by the microcontroller. This technology is used for data acquisition and transmission. The working of this module follows the same principle as the above mentioned working for the first module. The system has low energy consumption, large communication range and High stability characteristics. Can be used as the mobile Phone for deaf and dumb. Short distance as well as Long distance communication is possible.

Touch screen gesture method eliminates the use of Hand gesture movement sensing systems which are quite large, complex, expensive and slower. And also it is easy to carry unlike other hand held devices which have been used by them. Language learning mode helps even uneducated people to Learn English words through it [14].

There are many wearable communication devices developed for helping deaf-mute people but in this paper only a few methods which is more effective to access have been discussed.

Online Learning Methods:

Though there are various types of wearable communication devices available the main disadvantage is that if we misplace the device it will be very difficult for the person using it to communicate with others. So in order to overcome this there are some online learning methods were introduced. Even in online learning system there are numerous ways to eliminate demarcation between deaf and non-deaf people.

SLIM Module

First one is Sign Language Interpreter Module (SLIM). It presents sign language videos to deaf and hard hearing students (DHH) so that they can study on their own without the help of anyone. It is a multi model approach which combines audio, video, subtitles, media navigation controls into a single layer. SLIM consist mainly of three parts:

- Textual modality - subtitles
- Visual modality - sign language interpreter.
- Auditory modality - speech.

Many people preferred this SLIM system for learning because it has individual buttons for start, pause, stop the video etc..This module would enable them to integrate more easily into the social majority, but at the same time preserving their identity, improving their self image and developing their own culture and language [15]. It showed better results among the deaf rather than the classical method of education. The basic working of SLIM system is shown in figure 2.

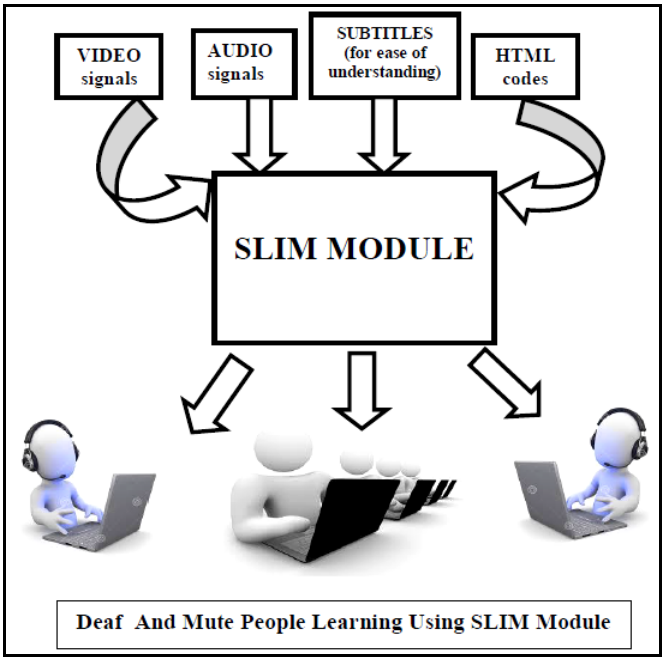

Figure 2: Slim Module

TESSA

Then there comes a system called TESSA, which is an experimental system that aims to aid transactions between a deaf person and a clerk in a Post Office by translating the clerk's speech to sign language. A speech recognizer recognizes speech from the clerk and the system then synthesizes the appropriate sequence of signs in British Sign language (BSL) using a specially developed avatar [16]. The Post Office clerk wears a headset microphone. There is an entropic speech recognizer which is active always and responds when the clerk utters a phrase that matches a "legal" phrase from the grammar. The screen in front of the clerk displays a menu of topics such as Postage, Bill Payments, Passports etc..
The software has the task of enabling communication between the speech recognition module and the avatar module and of controlling the overall progress of a transaction. The avatar module is written in C++ and communication is established using a remote procedure call system via TCP/IP socket connections [16]. For a specific application a video recording for each phrase is stored. The motion is captured with the help of Cyber gloves with 18 resistive elements for each hand which are used to record finger and thumb positions, magnetic sensors record the wrist, upper arm, head and upper torso positions in 3-D space relative to a magnetic field source. Facial movements are captured using a helmet mounted camera with IR [16].
The block diagram of TESSA system is shown in figure 3.

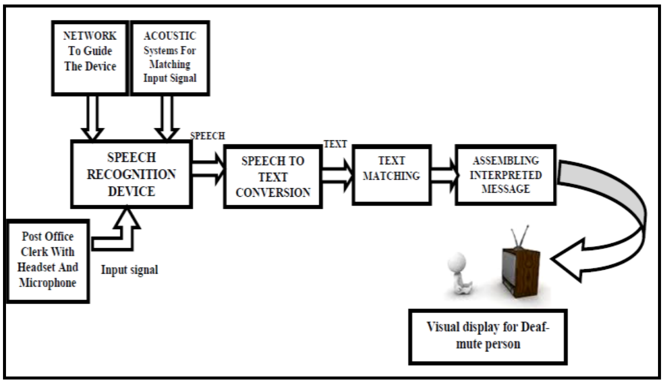

Figure 3: TESSA System

Wi-See Technology

With advancement in technology a wireless un-instrumented communication interpreter have been developed based on Wi-see technology especially for deaf and mute individuals. In Wi-see technology gesture recognition is done using conventional Wi-fi signals. The main advantage is that there is no instrumentation or sensing part used here. It is completely based on Doppler shift in frequency of Wi-Fi signals. Orthogonal Frequency Division Multiplexing (OFDM) modulation is being employed here. The minute Doppler shifts are extracted from wide-band OFDM signals. Pre-defined frequency patterns of the alphabets will be given to the system and later on will be checked if the English alphabet spoke at the receiver's end is matching the frequency patterns. This system involves the use of various modules such as gesture recognition, sign language analysis, speech analysis and synthesis, multimode interface that is made available to the deaf [17].
The Wi-Fi signal from known bandwidth is diverted or deflected by the hand motion in air. The starting gesture locks the target user and is received by the Wi-See receiver which has MIMO system which can differentiate multiple users since it has multiple antennas and can also look into the angle and direction in which the message is received from, this is further sent to the main computer for processing [17]. It has multicarrier system that divides RF bandwidth into multiple sub-channels and modulates data in each sub channel.

SWI_PELE System

In the past, they were using Telecommunications Device For Deaf (TDD).The deaf person will type the TDD message and the operator will read it aloud to the appropriate hearing person, and then the hearing person's reply was given again

through the operator. Due to the present advances in technology we can now make it wireless. The framework includes **Secure Wireless Infrastructures and Personalized Educational Learning Environments (SWI_PELE).**
The framework includes a scheme of servers, incorporates wireless infrastructure and personalized, multimedia based educational course material. The database system incorporates scope of lessons, videos, diagrams and small projects for each learning unit & can be accessed through mobile devices such as portable PCs, PDAs, and smart phones (see Figure 5).

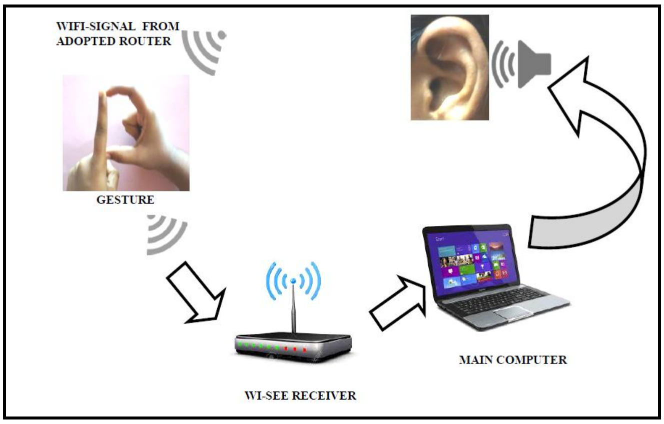

Figure 4: Wi-See Technology

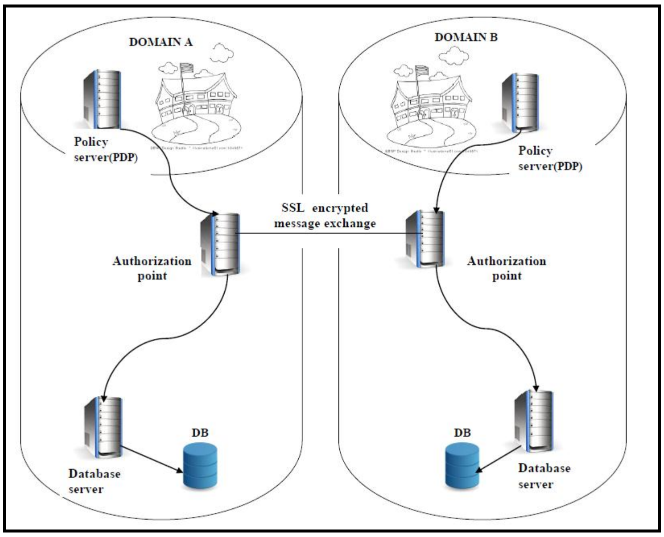

Figure 5: Overview of multi-domain framework of learning environments

During the lecture, a live connection to the web is established. Therefore, the D-HH students can easily access in a synchronous mode the PowerPoint slides of the teacher's presentation in their mobile devices, see teacher's notes and also previous slides of the ongoing presentation [18]. A major problem encountered is that D-HH students miss important information during presentations, because they must choose whether to watch the interpreter, the instructor, or the projected screen (slide) [18]. To avoid this problem, we include the slides, instructions, and videos in sign language into the syllabi. In this way they can teach both for the normal students and D-HH students at the same time (see figure 6).

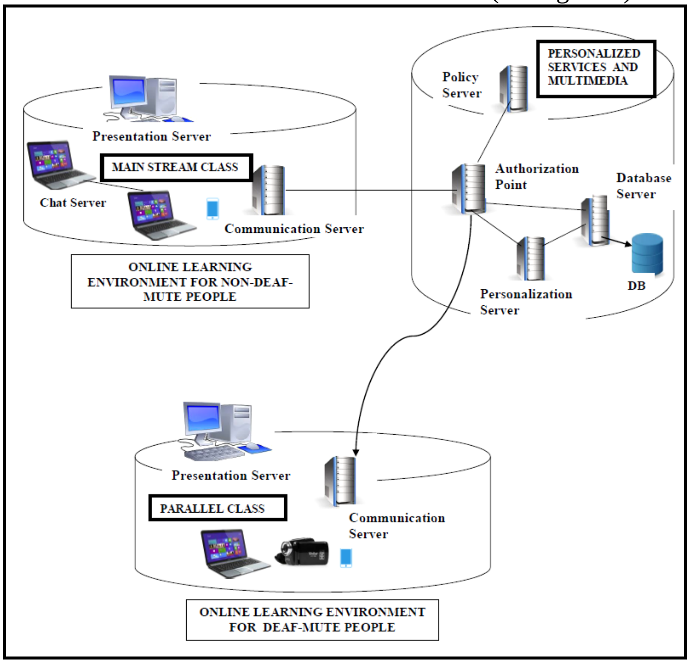

Figure 6: Organizational Scheme for Teaching Both Deaf And Non-Deaf People At The Same Time

Web Sign Technology

Another new approach for improving social interaction and communication among deaf and hard hearing people is Web Sign. It is a tool which permits to interpret automatically written texts in visual-gestured-spatial language using avatar technology [19]. Using cloud computing, virtual reality modeling a mobile translation service module was built.
However, many deaf people having sign language as their first or preferred language, the inputting and reading of written text messages can become even more difficult. In this context mms sign [20] was created to make available to people who are suffering from hearing impairment a service to facilitate communication using mobile phones. This service is mainly based on the transformation of SMS-Text to MMS containing the video sequence of translated text in sign language in a format which can be sent to deaf via MMS. This transformation is realized first with a generation of 3D animation using virtual character [21] then will be transformed to an MMS containing a 3GP video sequence.
The basic idea behind this approach is extraction of textual information from image. Furthermore, User with his Smartphone takes a picture that will be sent to the cloud. The service integrates a specialized Optical Character Recognition (OCR) that detects and extracts automatically all textual information. In the next step the extracted text will be sent as input to 3D rendering server to generate animation which contains the translation of input text to sign language using virtual character technology [19]. A general block diagram is shown in figure 7.

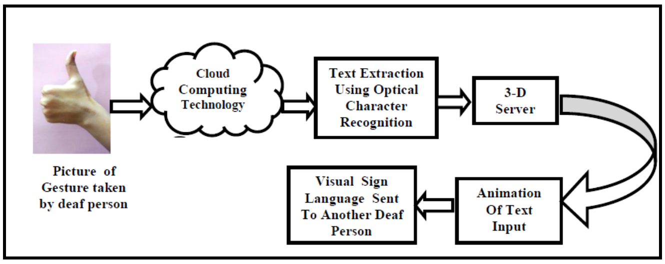

Figure 7: Communication Between Deaf And Hard Hearing People Using Web sign Technology

Conclusion

Without a communication interpreter it is very difficult for the deaf-mute people to communicate with non-deaf-mute people (figure 8). In this paper various technological developments that have improved the interaction among the deaf and non-deaf have been discussed. Two different strategies are drawn out in this paper.

Figure 8: Mute person unable to communicate with normal person

The first is using wearable communication devices such as gloves or using a touch screen device to communicate. The glove technology requires flex and tactile sensors along with an accelerometer embedded onto the glove. These sensors improves the ambiguity of the gestures made and thus will further improve the effectiveness of deaf language through gestures. This glove technology can be made more efficient by capturing the gestures once made by using additional accelerometers in the glove. Other handheld devices that can be used for deaf-mute communication are a keypad with an LCD screen or a Touch screen. It acts as a mobile phone and is used for data acquisition and transmission. Suitable low power hardware device can be chosen such that it has low power consumption and large communication range. Touch screen also eliminates the use of complex hand gestures and thus removes the need for hand movement sensing elements which are expensive and makes the process slow.

The next method of deaf mute communication is Online Learning System. In this online learning/E-learning system the medium of communication between deaf and non-deaf people is the internet or some web-based technology instead of wearable devices like gloves. This system plays an important role in educational growth of a nation especially for deaf mute people.

Some of the learning methods we discussed here include SLIM module, TESSA system, Wi-See technology, SWI_PELE system and Web sign technique. It is more advantageous than other interpretation methods like we need not carry or wear the hand held device always which we may tend to misplace and the main thing it is flexible to access for the people using it anytime anywhere and there are no restrictions for using it. It provides an effective and better learning platform for the deaf mute people and the learning process depends only on the user's interest. The only disadvantage is we cannot use it in the case of power failure and it is quite costly to acquire internet for poor people.

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