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Sign Language Recognition and Response via Virtual Reality

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Abstract

The main aim of this project is to provide a voice to voiceless people with the help of Python and Unity prototype systems. Aforesaid project work focuses on the problem of gesture recognition in real time that sign language is used by the community of deaf people. The problem addressed is based on Digital image processing using color segmentation, Skin detection, Image Segmentation, Image Filtering, and Template Matching techniques. This system recognizes gestures of ISL (Indian Sign Language) including the alphabet and a subset of its words.

Keywords: Sign language, Indian Sign Language (ISL), Digital Image Processing, Virtual Reality, Colour Segmentation, Image Filtering, Template Matching technique.

I. INTRODUCTION

In our day-to-day life, communication plays an important role in conveying information from one person to another person. But it becomes very difficult for people who are deaf and dumb to communicate with normal people. Sign language is the only way to communicate with them. But normal people are unaware of sign language. So there is only one way: to convert sign language into text, speech, and vice versa. That is known as sign recognition. Sign language is a combination of body language, hand gestures, and facial expressions. Among those, hand gestures are providing the majority of the information and hence the majority of the research is going on decoding hand gestures.

Normal people can communicate their thoughts and ideas to others through speech. The only means of communication method for the hearing- impaired community is the use of sign language. The hearing-impaired community has developed its own culture and methods to communicate among themselves and with ordinary people by using sign gestures. Instead of conveying their thoughts and ideas acoustically they convey them through sign patterns.

Sign gestures are a non-verbal visual language, different from the spoken language, but serving the same function. It is often very difficult for the hearing- impaired community to communicate their ideas and creativity to normal humans. This system was inspired by a special group of people who have difficulties communicating in verbal form. It is designed with ease of use for deaf or hearing-impaired people. The use of sign language is not only limited to individuals with impaired hearing or speech to communicate with each other or non-sign-language speakers and it is often considered a prominent medium of communication. Instead of acoustically conveyed sound patterns, sign language uses manual communication to convey meaning. It combines hand gestures and facial expressions with movements of other body parts such as eyes, legs, etc.

Some of the challenges experienced by speech and hard-of-hearing people while communicating with normal people were social interaction, communication disparity, education, behavioral problems, mental health, and safety concerns. How one can interact with acomputer either by using devices like a keyboard or mouse or via audio signals, while the former always need physical contact and the latter is prone to noise and disturbances. Physical action carried by the hand, eye, or any part of the body can be considered a gesture.

The essential aim of building a hand gesture recognition system is to create a natural interaction between humans and computers where the recognized gestures can be used for conveying meaningful information. Sign language is a very important way of communication for deaf- dumb people. In sign language, each gesture has a specific meaning. So therefore complex meanings can be explained with the help of a combination of various basic elements. Sign language is a gesture-based language for communication between deaf and dumb people. It is a non-verbal language that is usually used by deaf and dumb people to communicate more effectively with each other or normal people.

Sign language contains special rules and grammar for expressing effectively.There are two main sign language recognition approaches image-based and sensor- based. But lots of research is going on image-based approaches only because of the advantage of not needing to wear complex devices like Hand Gloves, Helmets, etc. like in the sensor-based approach. Gesture recognition is gaining importance in many applicationareas such as human interface, communication, multimedia, and security. Typically Sign recognition is related to image understanding. It contains two phases: sign detection and sign recognition. Sign detection is an extracting feature of a certain object concerning certain parameters.

This project proposes a system for recognizing signs used in ASL and interpreting them. American Sign Language (ASL) is a natural languagethat serves as the predominant sign language of deaf communities. Each signin ASL is composed of many distinctive components, generally referred to as parameters. A sign may use one hand or both. Figure 1.1 shows American Sign Language.

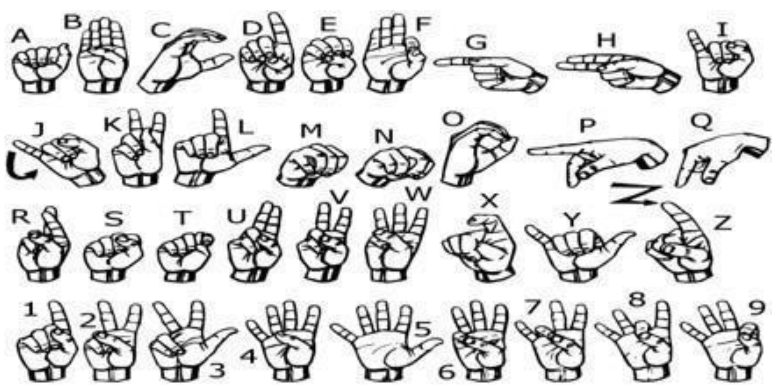


Figure 1.1 American Sign Language

II. LITERATURE SURVEY

[1] One of the important problems that our society faces is that people with disabilities are finding it hard to cope with fast-growing technology. Access to communication technologies has become essential for handicapped people. Generally, deaf and dumb people use sign language for communication but they find difficulty in communicating with others who don't understand sign language. Sign language is an expressive and natural way of communication between normal and dumb people (information is majorly conveyed through hand gestures). So, we need a translator to understand what they speak and communicate. The sign language translation system translates normal sign language to speech and hence makes communication But the question arises, of how the deaf person understands the speech of a normal person and hence we need a system that converts the speech of a normal person to text, and the corresponding gesture is displayed on display. So, the whole idea is to build a device that enables two-way communication between a deaf-mute person and a normal person.

[2] Communication is the process of exchanging information, views, and expressions between two or more persons, in both verbal and non-verbal manner. Hand gestures are the nonverbal method of communication used along with verbal communication. A more organized form of hand gesture communication is known as sign language. In this language, each alphabet of the English vocabulary is assigned a sign. The physically disabled person like the deaf and the dumb uses this language to communicate with each other. The idea of this project is to designa system that can understand sign language accurately so that less fortunate people may communicate with the outside world without the need for an interpreter. By keeping in mind the fact that in normal cases every human being has the same hand shape with four fingers and one thumb, this project aims at designing a real-time system for the recognition of some meaningful shapes made using hands.

[3] This application helps deaf and dumb people to communicate with the rest of the world using sign language. Suitable existing methods are integrated into this application. The key feature of this system is the real-time gesture- to-textconversion. The processing steps include gesture extraction, gesture matching, and speech conversion. Gesture extraction involves the use of various image processing techniques such as histogram matching, bounding box computation, skin color segmentation, and region growing. Techniques applicable for Gesture matching include feature point matching and correlation-based matching. We have come up with four different approaches based on the methods used for gesture extraction and matching. A Comparative study of these approaches is also carried out to rank them based on time efficiency and accuracy. The other features in the application include voicing out of text and text-to-gesture conversion.

[4] We describe a gesture-based device for deaf and dumb people as communication for a person, who cannot hear is visual, not auditory. Generally, dumb people use sign language for communication, but they find difficulty in communicating with others who don't understand sign language. So there is a barrier to communication between these two communities. This work aims to lower this barrier in communication. The main aim of the proposed project is to develop a cost-effective system thatcan give voice to voiceless people with the help of Smart Gloves. With the proposed work sign language is converted into text and speech using a flex sensor and microcontroller. It means that by using smart gloves communication will not be a barrier between two different communities .The paper proposes a

framework for recognizing hand gestures that would serve not only as a way of communication between deaf and dumb and mute people but also, as an instructor. Deaf and dumb individuals lack proper communication with normal people and find it difficult to properly express themselves. Thus, they are subjected to face many issues in this regard. Sign language is very popular among them and they use it to express themselves. Thus, there is a need for a proper translator. The deaf and dumb are not idle as past, they are working outside and doing great at it. So an efficient system must be set up, to interact with them, and to know their views and ideas. The framework here acts as a communication system for deaf and dumb individuals. It would take the sign language as an input which would display the result not only in the form of text but also in the form of audio. Similarly, if there is any input in the form of text, it would display the corresponding image.

[5] One of the most precious gifts of nature to human beings is the ability to express themselves by responding to the events occurring in their surroundings. Every normal human being sees, listens, and then reacts to the situations by speaking himself out. But some unfortunate ones are deprived of this valuable gift. This creates a gap between normal human beings and deprived ones. This application will help both of them to communicate with each other. The system mainly consists of two modules, first module is drawing out Indian Sign Language(ISL) gestures from real-time video and mapping them with human- understandable speech. Accordingly, the second module will take natural language as input and map it with equivalent Indian Sign Language animated gestures. Processing from video to speech will include frame formation from videos, finding the region of interest (ROI), and mapping of images with language knowledge base using a Correlational based approach then relevant audio generation using Google Text-to-Speech (TTS) API. The other way around, natural language is mapped with equivalent Indian Sign Language gestures by conversion of speech to text using Google Speech-to-Text (STT) API,further mapping the text to relevant animated gestures from the database.

[6] Deaf people may get irritated due to the problem of not being able to share their views with common people, which may affect their day-to-day life. This is the main reason to develop a such system that can help these people and they can also put their thoughts forward similar to other people who don't have such a problem. The advancement in Artificial intelligence provides the door for developing the system that overcomes this difficulty. So this project aims on developing a system that will be able to convert speech to text for the deaf person, and also sometimes the person might not be able to understand just by text, so the speech will also get converted to the universal sign language. Similarly, for mute people the sign language they are using will get converted to speech. We will take the help of various ML and AI concepts along with NLP to develop an accurate model. Convolutional neural networks (CNN) will be used for prediction as it is efficient in predicting image input, also as lip movements are fast and continuous so it is hard to capture so along with CNN, the use of attention-based long short-term memory (LSTM) will prove to be efficient. Data Augmentation methods will be used for getting better results. TensorFlowand Keras are the python libraries that will be used to convert the speech to text. Currently, there is much software available but all require network connectivity for it to work, while this device will work without the requirement of internet. Using the proposed model we got an accuracy of 100% in predicting sign language and 96% accuracy in sentence-level understanding.

[7] Over the years, communication has played a vital role in the exchange of information and feelings in one's life. Sign language is the only medium through which specially-abled people can connect to the

rest of the world through different hand gestures. With the advances in machine learning techniques, Hand gesture recognition (HGR) became a very important research topic. This paper deals with the classification of single and double-handed Indian sign language recognition using a machine learning algorithm with the help of MATLAB with 92-100% of accuracy.

[8] Recognition of sign language by hand gestures is one of the classical problems in computer vision. Conventional tools used for sign language translation involves the application of linear classifiers such as kNN and Support Vector Machine (SVM)to perform the classification of hand gesture images. However, these methods require sophisticated featuresfor classification. To automate the feature extraction and feature selection procedure, a Deep Neural Network (DNN)based machine translation is proposed in this work. Here, the images of English Sign Language (ESL)are identified using Deep Learning (DL)approach. A custom DNN with three convolution layers and three Max- Pooling layers are designed for this purpose. A top validation accuracy of 82% was obtained for the DNN structure proposed in this paper.

[9] With the application of deep learning in the field of computer vision, target detection, recognition, and target tracking technologies have been developed. Sign language recognition is currently a hot topic in the field of machine learning, and this project uses computer vision domain technologies to implement sign language recognition to solve the problems of deaf people in daily communication. In this project, two algorithm models, CNN+LSTM network structure and YOLOv5 target detection, are studied, and the functions of sign language recognition are implemented by the two algorithms respectively, and their implementation effects are compared, and the advantages and disadvantages of the two algorithms in sign language recognition are derived. Among them, YOLOv5 completes the task of sign language recognition by detecting hand movements, and its fast detection speed is more in line with the needs of life scenes and satisfies the demand for real- time sign language translation, which is more promising for application.

III. SYSTEM STUDY

A. LIMITATIONS OF EXISTINGSYSTEMS

o One of the major problems of the existing system is Dumb person should always carry the hardwarewith him.

o The user can’t do any other work with the flex sensor on the fingers and also sensor should be placed straight.

o The flex sensors can work only for alphabets, not for words or sentences and the accuracy is also low. To get more accurate results we need to use more sensors. Due to the usage of moresensors, it will becomevery expensive.

B. PROPOSED SOLUTION

In this project, we propose a system that makes use of a virtual reality headset to create an immersive environment for learning sign language. We show how features from data acquired by the Leap Motion controller, using an egocentric view, can be used to automatically recognize a user-signed gesture. The Leap features are used along with a random forest for real-time classification of the user's gesture. We further analyze which of these features are most important, in an egocentric view, for gesture recognition. To test the efficacy of our proposed system, we test the letters of the alphabet in Indian Sign Language. Once a letter is selected the user has as much time as needed to perform the correct gesture. To encourage users to continue using our learning tool, we have taken a ”relaxed” approach to incorrect gestures. The user will only receive feedback for a correct gesture, vs. an incorrect one. This is done to provide positive feedback and to mitigate any inaccuracies that may occur during classification. Due to the speed and reliability of random forests (with comparatively smaller training sets), we have chosen to use them for the classification of the ISL letters, in VR.As can be the Leap can accurately capture the gesture data (e.g. ISL letter)

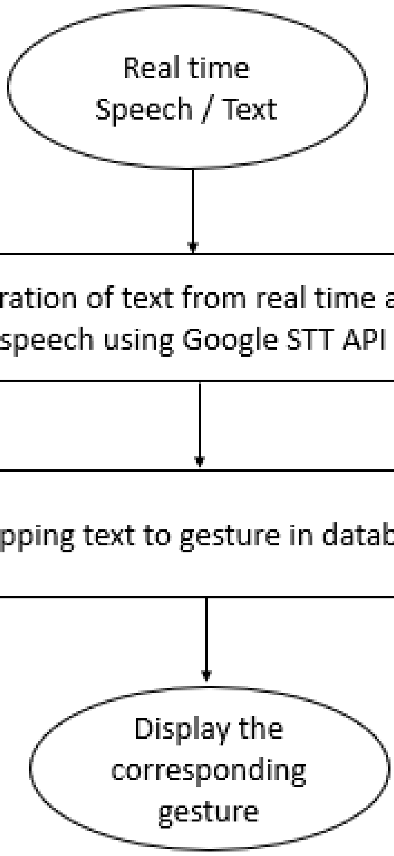


Fig.2.Flow Chart of Gesture-to- Text Conversion

that is being signed resulting in an accurate tool for teaching sign language in VR. Inversely, the whole sentence's information can be reconstructed and recognized with accuracy upon the established correlation between word units and sentences. Particularly, the segmentation approach assisted AI brings the capability of recognizing new/never- seen sentences that are not included in the database and are created by word element recombination in new orders. It provides a promising and universal solution to recognize new sentences and to readily expand the sentence database for practical communication of the speech/hearing disordered. Finally, the server-client terminals in VR space allow the displaying of sign recognition results and the direct typing of non- signers. The VR interface for two-way remote communication, linked with the AI front end for sign language recognition, shows a potential prototype of a future intelligent sign language recognition and communication system.

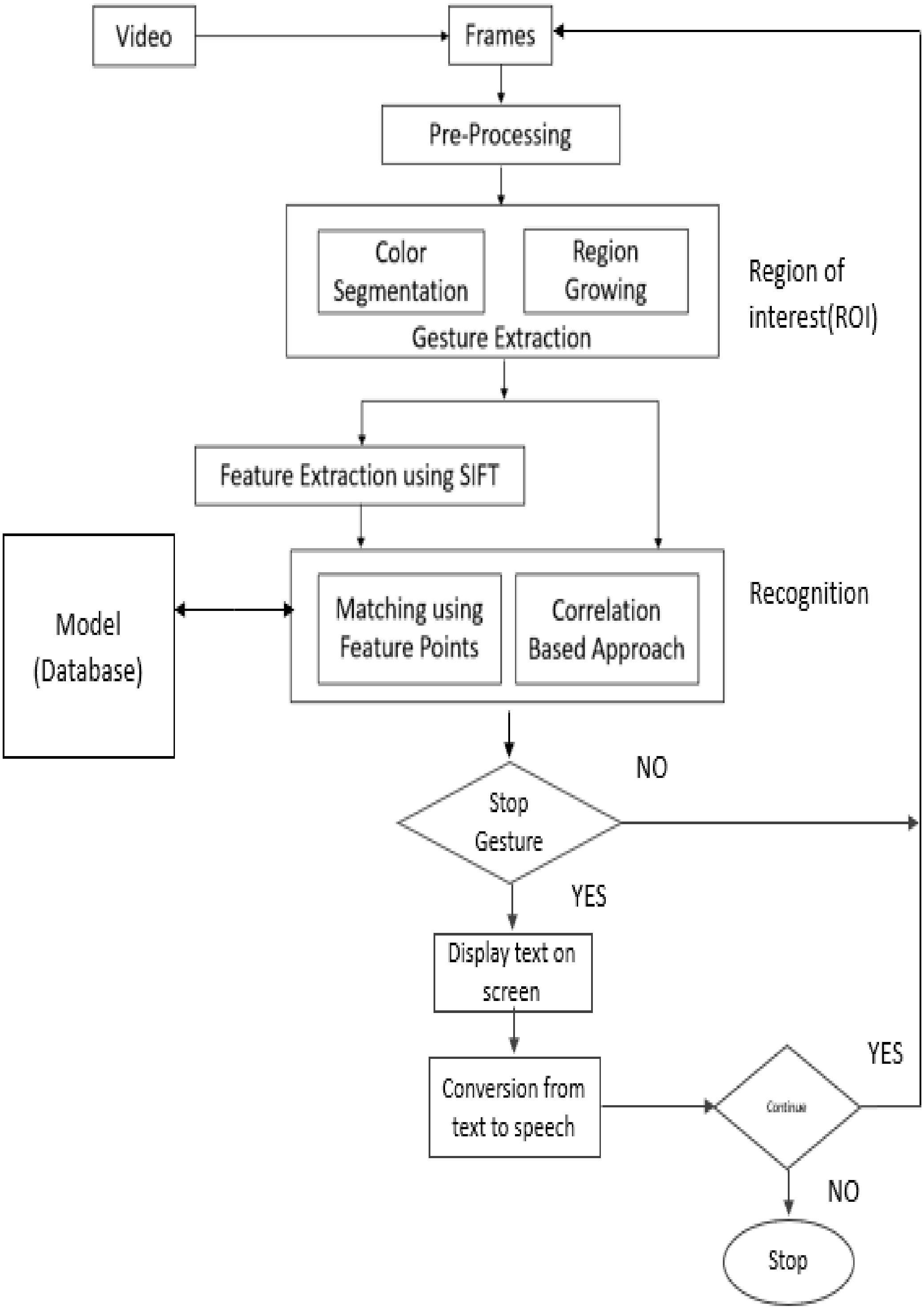


Fig.3.Flow of Speech/text to gesture in VR

a) INPUT

The image is taken using the camera in this initial step of the suggested framework. It is also known as image acquisition. The input image is then shrunk to lessen computing complexity and mistakes. The query image is in RGB format as shown in figure 4.

Fig.4 Input RGB image

b) SKIN SEGMENTATION

This crucial step involves identifying the skin region. The Hue-Saturation- Value (HSV) histogram is used for this. It takes into account any variations in lighting. The range is taken into account for all potential skintones, from dark to light. In order to generate the mask needed to find the desired region. The noise is then removed to create a clean image with edges that can be detected, and the region of interest is then obtained. Next, the median filter is applied, followed by morphological procedures. where the picture comparison is carried out.

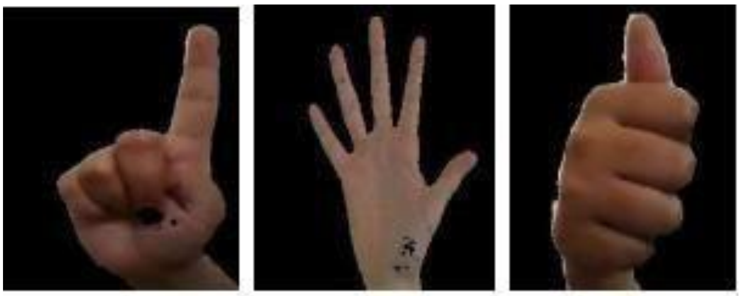


Fig. 5. Skin detection of an input image

c) FEATURE EXTRACTION

This is an important part. The features are extracted using the Harris algorithm. It detects the necessary interest points in the form of an Nx2 matrix, where N is the number of feature points extracted. The first column gives the row position of the interest points and the second column gives the column position of the interest points It then draws those points on the query image, as shown in Figure 4. The region of interest is converted to a gray- level image on which this algorithm is to be applied. Firstly, the derivative mask is composed considering some luminance value. The image derivative is then calculated. Afterward, the local maxima of the neighborhood are calculated. Hence, the threshold value can beset. The local maxima greater than the threshold serve as the interest points, while the rest are excluded. The evaluation of interest points is done by referringto[4].

This matrix A averages the derivative of the signal in a window W around a point (x, y):

$$A(x, y) = \begin{bmatrix} \sum_{W} (I_x(x_k, y_k))^2 & \sum_{W} I_x(x_k, y_k) I_y(x_k, y_k) \\ \sum_{W} I_x(x_k, y_k) I_y(x_k, y_k) & \sum_{W} (I_y(x_k, y_k))^2 \end{bmatrix}$$

where I(x, y) is the image function and (xk, yk) are the points in the window W around (x, y)[4].

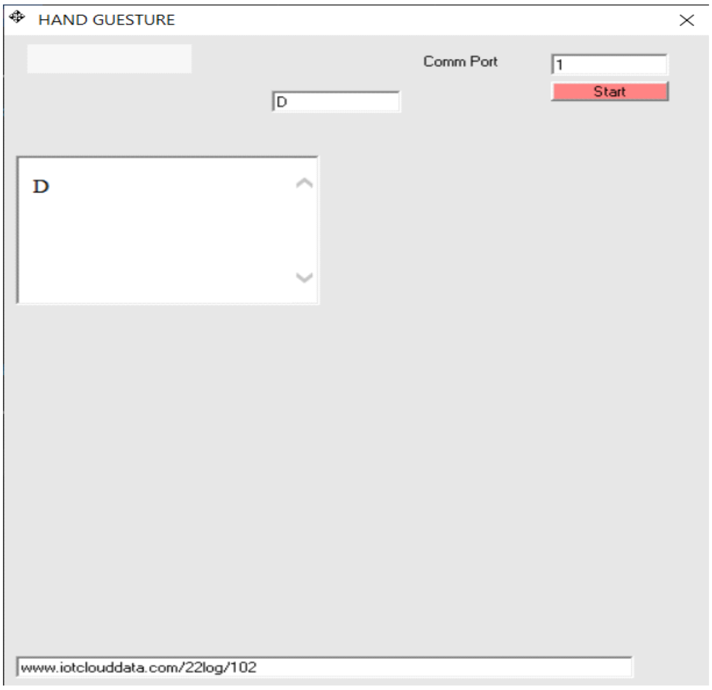
Fig. 6. Feature Extraction

d) FEATURE MATCHING AND RECOGNITION

The most crucial step, feature matching, follows the extraction. Every standard image's features have already been retrieved and placed in the data set as an Nx2 matrix. mat file with a matrix. The query image's matrix value is then compared to each of those in the data set for each image. To get the desired outcome, the minimal distance between thematched characteristics is determined. The greatest matching image is the one with the lowest value. The outcome is presented both as text and audio (for visually impaired people whocannot read text). As a result, the anticipated outcome was possible.

e) INTEGRATING COMPUTER VISION AND MACHINE LEARNING ALGORITHMS

To achieve sign language recognition and response in Unity, computer vision algorithms can be used to detect and track the sign language gestures made by the user. Machine learning algorithms can then be used to classify the gestures and generate a corresponding response.



IV. SOFTWARE REQUIREMENTS MECHANIZE

Mechanize gives you a browser-like object to interact with web pages. Mechanize Browser implements the urllib2.OpenerDirector interface. Browser objects have a state, including navigation history, HTML form state, cookies, etc. The set of features and URL schemes handled by Browser objects is configurable. The library also provides an API that is mostly compatible with urllib2. Features of Mechanize browser include FTP, HTTP, and file: URL schemes, browser history, hyperlink, and HTML form support, HTTP cookies, HTTP-EQUIV and Refresh, Referer header, robots.txt, redirections, proxies, and Basic and Digest HTTP authentication. Mechanize works with Python 2.4, Python 2.5, Python 2.6, and Python.

CHROMIUM

Chromium is an open-source browser project that forms the basis for the Chrome web browser. Chromium is started by Google, to provide the source code for the proprietary Google Chrome browser. When Google first introduced Chrome back in 2008, they also released the Chromium source code on which Chrome was based as an open- source project. That open-source code is maintained by the Chromium Project while Chrome itself is maintained by Google.

Google takes Chromium and then adds thefollowing:

- AAC, H.264, and MP3 Support. Chrome includes licensed codecs for these proprietary media formats, giving you access to a wider variety of media content— particularly sites using HTML5 video to stream H.264 videos. Both browsers include the basic, free codecs: Opus, Theora, Vorbis, VP8, VP9, and WAV.

- Adobe Flash (PPAPI)

Chrome includes a sandboxed Pepper API (PPAPI) Flash plug-in that Google automatically updates along with Chrome. Even on Windows and Mac, you're better off with the sandboxed PPAPI Flash plugin from Chrome rather than the older NPAPI Flash plug-in available from Adobe's website.

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- Google Update

Windows and Mac users of Chrome get an extra background app that automatically keeps Chrome up-to- date. Linux users use their standard software management tools.

- Extension Restrictions

For Chrome, Google disables extensions that are not hosted in the Chrome Web Store.

Crash and Error Reporting

Users of Chrome can opt to send statistics on crashes and errors to Google for analysis.

o Security Sandbox

Google also notes that some Linux distributions may disable Chromium's security sandbox, so you'll want to navigate to about: sandbox in Chromium to ensure the sandbox is enabled and functioning by default. This is one of Chromium's best features.

On Linux, you can often install Chromium directly from your Linux distribution's software repositories. On Ubuntu Linux, for example, you can install it by opening the Ubuntu Software Centre, searching for Chromium, and then clicking Install. Chromium gets updated with security updates through your Linux distribution's software repositories.

TESSERACT OCR

Optical Character Recognition is the process of electronically extracting text from images and reusing it in a variety of ways such as document editing, free-text searches, or compression.

Optical Character Recognition is a technology that enables you to convert different types of documents, such as scanned paper documents, PDF files, or images captured by a digital camera into editable and searchable data.

Python-Tesseract is an optical character recognition (OCR) contrivance for python. It will be familiarized and understand the text embedded in icons. It is binding for goggles' OCR. It is too functional and a stand-alone incantation script to Tesseract, as it can read all facsimile types reinforced by the Python Imaging collections and others, whereas Tesseract-occur by default, it

ropes tiff and bmp. To boot, if practiced as a script, Python-Tesseract will print the recognized text instead of writing it to a file.

The Tesseract engine was originally developed as proprietary software at Hewlett Packard labs in Bristol, England, and Greeley, Colorado between 1985 and 1994, with some more changes made in 1996 to port to Windows, and some migration from C to C++ in 1998. A lot of the code was written in C, and then some more was written in C++. Since then all the code has been converted to at least compile with a C++ compiler. It was then released as open source in 2005 by Hewlett Packard and the University of Nevada, Las Vegas (UNLV). Tesseract development has been sponsored by Google since 2006.

There are two parts to install in tesseract OCR the engine and the training data for a language. Tesseract is available directly from many Linux distributions. Packages are also generally available for language training data unpack it and copy the trained data file into the 'Tess data' directory. You can install Tesseract using either Mac-Ports or Homebrew.

Tesseract has Unicode (UTF-8) support and can recognize more than hundreds of languages "out of the box". It can be trained to recognize other languages. Tesseract supports various output formats: plain text, html, and pdf. To get better OCR results, we need toimprove the quality of the image you are giving Tesseract. The latest stable version is 3.05.00. Developers use lib tesseract C or C++ API to build their applications.

Tesseract Features:

- Page layout analysis.
- More languages are supported.

- Improve forecast accuracy.
- Add UI.

OPENCV

OpenCV is an open-source computer vision library. The library is written in C and C++ and runs under Linux, Windows, and Mac OS X. There is active development on interfaces for Python, Ruby, Matlab, and other languages. OpenCV was designed for computational efficiency and with a strong focus on real-time applications. OpenCV is written in optimized C and can take advantage of multicore processors. If you desire further automatic optimization on Intel architectures, you can buy Intel's Integrated Performance Primitives (IPP) libraries, which consist of low- level optimized routines in many different algorithmic areas. OpenCV automatically uses the appropriate IPP library at runtime if that library is installed. One of OpenCV's goals is to provide a simple-to-use computer vision infrastructure that helps people build fairly sophisticated vision applications quickly. The OpenCV library contains over 500 functions that span many areas in vision, including factory product inspection, medical imaging, security, user interface, camera calibration, stereo vision, and robotics. Because computer vision and machine learning often go hand-in-hand, OpenCV also contains a full, general-purpose Machine Learning Library (MLL). This sub-library is focused on statistical pattern recognition and clustering. The MLL is highly useful for the visual tasks that are at the core of OpenCV's mission, but it is general enough to be used for any machine learning problem. OpenCV is a compilation of encoding functions primarily aimed at factual-time computer vision, originally shaped by Intel research and subsequently supported by Willow Garage and now maintained by Itseez. It is a collection of cross-platform and free for use under the open source. OpenCV includes foremost changes to the C++ interface, aiming at ease, more case- safe designs, and better implementations for existing ones in terms of execution. It is used f o r diverse purposes including Facial recognition systems, Gesture recognition, and Motion understanding. OpenCV has played a role in the growth of computer vision by enabling thousands of people to do more productive work in vision. With its focus on real-time vision,

OpenCV helps students and professionals efficiently implement projects and jump-start research by providing them with a computer vision and machine learning infrastructure that was previously available only in a few matureresearch labs.

The CV component contains the basic image processing and higher-level computer vision algorithms, ML is the machine learning library, which includes many statistical classifiers and clustering tools. High GUI contains I/O routines and functions for storing and loading video and images, and CX Core contains the basic data structures and content.

UNITY

Unity is a popular cross-platform game engine and development environment that enables the creation of interactive 2D and 3D applications and games. Unity is a game engine and development environment that provides a comprehensive suite of tools for creating interactive applications and games. It was first released in 2005 and has since become one of the most popular game engines in the world. Unity supports a wide range of platforms, including PC, consoles, mobile devices, and VR/AR devices.

The following are the features of Unity Engine:

- Cross-platform development
- Advanced graphics capabilities
- Built-in physics engine
- Scripting and programming

V. CONCLUSION AND FUTURE SCOPE

The deaf and dumb are not sitting in the house as past, they are working outside and doing great. So an efficient system must be set up, to interact with them. Sign language is very popular among them and hand gesture recognition is just a small part of it.

The proposed system aims at bridging the communication gap between two strata of society. A considerable amount of work has been done previously in this domain, but this paper adds complete both-way communication efficiently because the system will be implemented as a handy mobile application. So, it truly serves its needs in all aspects. The above-specified strategies prove efficient in terms of time a n d accuracy. Further enhancements, can be made in terms of implementing the communicator with other sign languages like Indian Sign Language, accent recognition for various ascents throughout the globe, emotion recognition in sign language, and language translation.

In this paper, we have designed the prototype model for blind, deaf, and dumb people by employing a single compact device. The important keyfactor of this project is to facilitate these people and to fix them more confident to manage their sites by themselves. The primary advantage is that the device can be taken away easily and is of about less weight.

To further this project can be followed out with any other advanced devices by using simple coding language to get it less complicated. The complication can be reduced by a tiny gadget which could be more useful to those people in this electronic world.

The proposed system fulfills the hand gesture recognition process but with some limitations, as both hands cannot be used with this technique, and the results are not that efficient. Proper light conditions help in the easy detection of the region of interest. The system can be further expanded for alphabets. Like numbers, each alphabet has its unique gesture. Thus, detection and recognition would beefficient using this technique. Not only this, the input can be taken in the form of videos. The videos can then be divided into frames. From those frames, the necessary hand region could be extracted using a bounding box and then following the same procedure as mentioned in the proposed framework. Every language has its grammar. Sign language has it as well. Byrecognizing the frame images and using a proper parsing algorithm, a grammatical structure could be formed. This would take the system of hand gesture recognition a step ahead. This system can be made handy by incorporating it int o a mobile phone. With just a click, the image is captured and the corresponding result is obtained. Thus, a more efficient way of interaction could be achieved.

The system can be further expanded for the alphabet, and numbers in gesture control. The input can be also taken in the form of videos and the videos are divided into frames and the frames can be converted into text. We can also add grammatical structure for sign language. The system can be made handy by incorporating it into a mobile phone.

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