

# Sign Language Translation System

Rosemary Antony, Silji Simon C, Stephy Paul, Scaria Alex

Dept. of Computer Science  
Sahrdaya College Of Engineering and Technology  
Thrissur, India

rosemarypallipadan@gmail.com, siljimonc@gmail.com,stephyaulachandy@gmail.com,scariaalex@sahrdaya.ac.in

**Abstract – Communication is the only medium by which we can share or express our thoughts, but for a person with disability faces difficulty in communicating. In our society, communication has a major role. The number of deaf and dumb are increasing in our world. A community consists of abled persons and disabled persons. For dumb people, it is impossible for them to communicate with others. It is difficult for ordinary people to learn the sign language for communication. So this system will help the dumb people to interact with normal people. Still there are some existing methods to overcome this issue, that are sign language to text conversion and using smart gloves. But all these have their own limitations. In the existing systems signs are identified from images. The normal outputs will be numbers or alphabets and connective words like is, are etc may not be handled. Wearing gloves are not comfortable for the users. If signs are converted to voice rather than text, it will be very helpful for dumb people. In this system the person will show the sign language before a webcam and it will capture the hand gesture from video and predict the symbol. Machine learning is the domain of this system. The final result will be voice. Here we are identifying signs from live video. It is the main difference from other methods. The output will be in a sentence which means a collection of words. For handling connectives special languages were implemented.**

**Keywords– Machine learning, feature extraction.**

## I. INTRODUCTION

Speech impairment is a disability which affects an individual's ability to communicate using speech. Then people who are affected by this use other media of communication such as sign language. Sign Language enhances the understanding ability for physically impaired people in speech and hearing all over the world. It utilizes complete sign which is made with facial expression, hand and other parts of our body. Every country uses their own sign language is concerned about their own syntactical and grammatical meaning. British Sign Language (BSL) and American Sign Language (ASL) are the sign languages, and the language which is being used in India is called Indian Sign Language (ISL). But still ISL is not an official sign language of India in spite of 6 millions deaf and dumb populations. The dumb people sharing their thoughts and emotions through their respective sign language. In our society it is very difficult for the dumb people to communicate with the normal people, unless and until normal people like us learn the sign language for the purpose of communication. The sign language of dumb people is difficult to learn and it is not possible for everyone to learn that language. That's why this community becomes isolated from others, they cannot express their self. So ordinary people cannot come and share their thoughts with these physically impaired people. Any non-verbal communication like motion of

face, hands and other part of body is a form of gesture. Gesture recognition or sign language recognition enables computer to understand human actions.

In this situation we developed a sign language translation to voice for dumb people. This was improved the communication with the people who has speeching difficulties. In this system webcam is placed in front of the impaired person. Then the person show sign language in front of the web camera. The webcam captured the hand gesture and performed image processing. This model takes video sequences and extracts temporal and spatial features from them. The features captured was mapped with the one previously stored. So correspondingly exact picture from the database was identified. Also we introduced another special sign language for connecting words like is, are etc. Then in this way physically impaired person was able to go through the entire sentence that he wants to communicate. Here used Continuous Sign language sequence of gestures and that generated a meaningful sentence. After that this sentence was translated into voice. So that it would be audible to everyone. Extraction of visual information is an important part in gesture recognition. There are another parts like segmentation of hand from the background and environment, tracking of hand, illumination variation, movements occlusion, and position etc. Different techniques have been developed for pattern classification towards dynamic gestures. The classification approach is based on the hand shape, hand gestures trajectory and hand motion.

## II. PROBLEM DEFINITION

Disability is a problem which make difficult or impossible in speech,walk,hear etc. It will be by birth or due to some tragic incidents in life. About millions of people are deaf and dumb around us. A person is mute(dumb) if he cannot speak. Communication between mute and normal persons have always been a challenging task. Effective communication will enhance the confidence,self-esteem. Sign language helps dumb people to communicate with other people. But not all people understand sign language. So this system will help dumb people to communicate with normal people. Even if there are some other technologies to help in their communication it may not be convenient for everyone.

This system will help to translate sign language to voice only with the help of laptop or pc. Here the person only want to show the gesture before the webcam. Signs are capturing from the live video and converted to voice. Captured frames are comparing with the trained dataset and it recognizes the word. There are connecting words in a language like is,are etc. Here some signs are specially allotted for those words. This will help to provide a complete sentence. Any other special equipment are not using here.

## III. RELATED WORK

Language (SL) is commonly known to be the primary language of deaf people, and usually captured in the form of video. In [1] Runpeng Cui, Hu Liu, and Changshui Zhang, they developed a continuous SL recognition framework with deep neural networks, which directly converts videos of SL sentences to sequences of ordered gloss labels. A deep convolutional neural networks with stacked temporal fusion layers as the feature extraction module, and bi-directional recurrent neural networks as the sequence learning module were using. Here, end-to-end recognition model is trained first for alignment proposal, and then use the alignment proposal as strong supervisory information to directly tune the feature extraction module.

Sign Language Recognition for Deaf and Dumb People [1], using android environment application paved a way for the deaf person who can easily interact with normal person anywhere. This project also supports Automatic translation, automotive speech recognition, and Speech-to-sign transmission. The system includes a variety of technologies. It consist two main parts hardware and software. The overall system architecture is shown in fig 1. In hardware parts required phone, speaker. In software mainly consider outfit-7. All these parts can be brought together in an integrated system. In the system implementation of outfit-7 in VSR application. Outfit-7 is an application for the mobile phone, with the software, which will convert everything we say in a high pitched

voice. Without dialling number this application can be used.

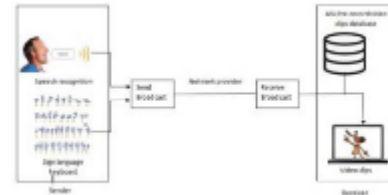


Fig. 1. Overall system architecture.

Translation of Sign Language for Deaf and Dumb People [2], uses the recognition of sign language involves pre-processing level and classification level. Pre-processing level involves gray scale conversion, noise reduction, background subtraction, brightness normalization and scaling operation. Classification levels involves feature extraction using Otsu's algorithm and classification using SVM classifier for gesture recognition. Real time gestures which are made by deaf and mute people is captured in various orientation. This is used as database image. Real time gesture is captured and it is given as input to the pre-processor stage. The color image is converted into gray scale for better classification. Noise can be added to the image and median filter is used to reduce the unwanted noise component and to remove the unwanted background present in image. Then, Features are extracted from this image using otsu algorithm in the feature extraction process. After extracting the features from image, the feature extracted from captured image is compared with feature extracted from stored database image. when it matches, the text and speech for corresponding sign is obtained. Therefore, the text and speech for corresponding sign can be obtained with high accuracy rate.

Conversation of Sign Language to Speech with Human Gestures [3], produces speech/ voice to sign language with simple human gestures and motion sensing technology with the help of Microsoft's Kinect sensor. This paper started its initiations in the vision to successfully reduce the human machine interaction and to take up the Natural User Interface at the forefront. The initial phase of the paper began in controlling a simple PowerPoint presentation with gestures like moving hands from left to right or moving from right to left to move between PowerPoint slides. The next phase of the project is controlling electrical appliances with human gestures. The paper was motivated on understanding the sign language and producing speech.

Translating Indian Sign Language to text and voice messages using flex sensors [4], uses the gloves, which are fitted with flex sensors to trace the correct movement of the fingers. For each flex sensor the required voltage are supplied initially. According to the fingers movement there can be a voltage drop associated with it because of the variation in the resistance. It is due to bending of the

flex sensor. The voltage thus obtained will be analog in nature. This analog voltage is converted to digital voltage using an analog to digital converter and this voltage is fed to microcontroller AT89S52.

Sign Language Problem And Solutions For Deaf And Dumb People [5], solve the problem by introducing methods as Speech to Sign Language Interpreter System, Hidden Markov Model Toolkit, Indian Gestural Interaction Translator, ANN, Hidden Markov model and Support Vector Machine. The examples of symbols are shown in fig 2.



Fig. 2. Examples of sign language symbols.

A classifier is needed in sign language recognition to classify the input signs into different classes. The feature vector obtained from the training database is used to train the classifier during the training phase. When a test input is given, the trained classifier identifies the class corresponding to the sign and displays the text or plays the sound. The test inputs can be images or videos. Hidden Markov Model Toolkit is software toolkit for handling HMMs. It is mainly intended for speech recognition, but has been used in many other pattern recognition applications that employ HMMs, including speech synthesis, character recognition and DNA sequencing. Indian Gestural Interaction Translator Based on the above analysis, Ingit adopts a formulaic approach that directly generates the semantic structure where possible (about 60 defaults to a compositional mode for the others). An artificial neural network involves a network of simple processing elements (artificial neurons) which can exhibit complex global behavior, determined by the connections between the processing elements and element parameters. It consists of an interconnected group of artificial neurons and processes information using a connectionist approach to computation. In most cases an ANN is Sign Language Problem And Solutions For Deaf And Dumb People This paper says about various ways to solve the problem by introducing different methods such as Speech to Sign Language Interpreter System, Hidden Markov Model Toolkit, Indian Gestural Interaction Translator, Artificial Neural Networks, Hidden Markov model and Support Vector Machine. A classifier is needed in sign language recognition to classify the input

signs into different classes. The feature vector obtained from the training database is used to train the classifier during the training phase. When a test input is given, the trained classifier identifies the class corresponding to the sign and displays the text or plays the sound. The test inputs can be images or videos.

Hidden Markov Model Toolkit is software toolkit for handling HMMs. It is mainly intended for speech recognition, but has been used in many other pattern recognition applications that employ HMMs, including speech synthesis, character recognition and DNA sequencing. Indian Gestural Interaction Translator Based on the above analysis, Ingit adopts a formulaic approach that directly generates the semantic structure where possible (about 60 defaults to a compositional mode for the others). An artificial neural network involves a network of simple processing elements (artificial neurons) which can exhibit complex global behavior, determined by the connections between the processing elements and element parameters. It consists of an interconnected group of artificial neurons and processes information using a connectionist approach to computation. In most cases an ANN is an adaptive system which changes its structure based on external or internal information that flows through the network during the learning phase. The utility of artificial neural network models lies in the fact where they could be used to infer a function from observations. There are several neural networking algorithms which can be used for gesture recognition. The different networks are feed forward networks, Elman neural networks, Self-propagation algorithms available for training the neural networks. A Hidden Markov model collection of finite states connected by transitions. Each state is characterized by two sets of probabilities: a transition probability and either a discrete output probability distribution or continuous output probability density function which, given the state, defines the condition probability of emitting each output symbol from a finite alphabet or a continuous random vector. The SVM is a popular pattern recognition technique with supervised learning. Since it divides the feature space for each class, the SVM can handle unknown data well, although it is not suited to grouping sample data. It is originally developed by Vapnik and colleagues at bell laboratories. It was actually developed for solving binary decision problems. The basic SVM takes a set of and predicts, given input, which of two possible classes forms the output. Thus, it can be called as a non probabilistic binary linear classifier. For multiclass problems, such problems are decomposed into several two class problems that can be addressed directly using several SVMs. An adaptive system that changes its structure based on external or internal information that flows through the network during the learning stage. The utility of artificial neural network models lies in the fact where they could be used to infer a function from observations. There are several neural networking algorithms which can be used for gesture recognition. The different networks are feed

forward networks, Elman neural networks, Self propagation algorithms available for training the neural networks.

A Hidden Markov model refers to a collection of finite states connected by transitions. Each state is characterized by two sets of probabilities: a transition probability and either a discrete output probability distribution or continuous output probability density function which, given the state, defines the condition probability of emitting each output symbol from a finite alphabet or a continuous random vector. The SVM is a popular pattern recognition technique with supervised learning. Since it divides the feature space for each class, the SVM can handle unknown data well, although it is not suited to grouping sample data. It is originally developed by Vapnik and colleagues at bell laboratories. It was actually developed for solving binary decision problems. The basic SVM takes a set of input and predicts, for each given input, which of two possible classes forms the output. Thus, it can be called as a non-probabilistic binary linear classifier. For multi-class problems, such problems are decomposed into several two-class problems that can be addressed directly using several SVMs.

Hand Talk: Intelligent Sign Language Recognition for Deaf and Dumb [6], system introduces an efficient and fast algorithm for identification of the amount of fingers opened during a gesture representing an alphabet of the Binary signing. The idea consisted of designing and building up an intelligent system using group of Flex sensor, machine learning and AI concepts to require visual inputs of sign language's hand gestures and generate easily recognizable sort of outputs. The objective of this project is to develop an intelligent system which may act as a translator between the signing and therefore the speech dynamically and can make the communication between people with hearing disorder and normal people both effective and efficient. After recognizing the gesture the output are shown in terms of voice and text for display.

Multiple Sign Language Translation into Voice Message [7], presents the solution for deaf and dumb people generally dumb people use signing for communication, but they find difficulty in communicating with others who don't understand sign language. This system aims to lower this barrier in communication. It is based on the need of developing a device which will translate sign language into speech so as to form the communication take place between the mute communities and therefore the general public as possible. A Wireless data glove which is a normal cloth driving glove fitted with flex sensors is employed along the length of each finger and the thumb. Mute people can use the gloves to perform hand geMultiple Sign Language Translation into Voice Message presents the solution for deaf and dumb people generally dumb people use signing for communication,

but they find difficulty in communicating with others who don't understand sign language. This system aims to lower this barrier in communication. It is based on the need of developing a device which will translate sign language into speech so as to form the communication take place between the mute communities and therefore the general public as possible. A Wireless data glove which is a normal cloth driving glove fitted with flex sensors is employed along the length of each finger and the thumb. Mute people can use the gloves to perform hand gesture and it'll be converted into speech in order that normal people can understand their expression. A sign language usually provides sign for whole words. It can also provide sign for letters to perform words that don't have a corresponding sign in that sign language. Flex Sensor plays the main role, Flex sensors are the sensors whose resistance changes depending on the amount of flexion experienced by the sensor. Here the device recognizes the sign language Alphabets and Numbers. It is in the process of developing a prototype to reduce the communication gap between differentiable and normal people. The program is in embedded C coding. Arduino software is used to see the working of the program in the hardware circuitry which is designed using microcontroller and sensors. Sture and it'll be converted into speech in order that normal people can understand their expression. A sign language provides sign for whole words. It also provides sign for letters to perform words that don't have a corresponding sign in that sign language. Flex Sensor plays the main role, Flex sensors are the sensors whose resistance changes depending on the amount of flexion experienced by the sensor. Here the device recognizes the sign language Alphabets and Numbers. It is in the process of developing a prototype to reduce the communication gap between differentiable and normal people. The program is in embedded C coding. Arduino software is used to see the working of the program in the hardware circuitry which is designed using microcontroller and sensors.

Conversion of Sign Language into Text [8], shows the sign language recognizing of 26 hand gestures in Indian sign language using MATLAB. The system contains four modules such as: preprocessing and hand segmentation, feature extraction, sign recognition and sign to text. By using image processing the segmentation can be done. Some of the features are extracted such as Eigen values and Eigen vectors which are used in recognition. The system overview is described in fig 3. The linear discriminant analysis algorithm was used for gesture recognition and recognized gestures are converted into text and voice format. The proposed system helps to dimensionality reduction.

Conversion of Sign Language into Text [9], shows the Communication between Deaf-Dumb People and Normal People: Chat Assist was developed according to the prototype methodology.

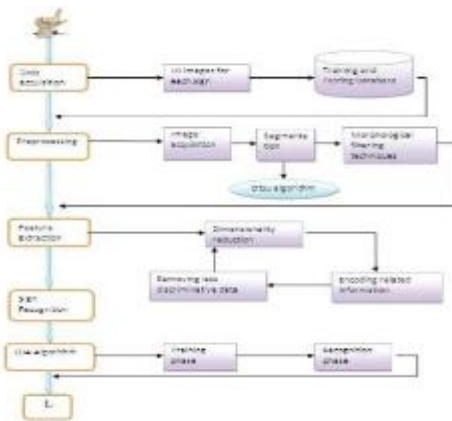


Fig. 3. System overview of sign language recognition.

The necessity to run many iterations of the system phases. Therefore prototype methodology was selected to implement this system. The the research team gathered requirements about android chat application structures, hard-

ware resources and software resources that were used for develop a talk applications. Then developed the time frame for the system to complete within one year. The initiative state of the system, the research team divided the entire research component into four sub research components. Then the research team researched about Sinhala sign language signs and the way those signs were created etc. Then the Gantt chart created has indicated tasks and allocated time for each task. Then feasibility analysis was done for clarify that this system is possible for develop to research team. The research group had skilled around twenty research papers and analyzed the details of the similar systems. The research team decided to design emoticons for those signs. They observed the idea of normal people about the android chat application. Then had a survey by creating questionnaires. Around three hundred participants were participate to this survey. 90.9participants' parentage has given positive response for this project.

Real-Time American Sign Language Recognition Using Skin Segmentation and Image Category Classification [10], with Convolutional Neural Network and Deep Learning is a real-time sign language translator is an important milestone in facilitating communication between the deaf community and the general public. We hereby present the development and implementation of an American Sign Language finger spelling translator based on skin segmentation and machine learning algorithms. System present an automatic human skin segmentation algorithm based on color information. The YCbCr color space because typically video coding and provides use of chrominance information for modeling the human skin color. They modeled the skin-color distribution as a bivariate normal distribution in the CbCr plane. The performance of the algorithm is illustrated by simulations on images depicting people of different ethnicity. Then Convolutional Neural Network to extract

features from the images and Deep Learning Method is used to train a classifier to recognize Sign Language.

American Sign Language Recognition using Deep Learning and Computer Vision [11], uses a speech impairment is a disability which affects an individuals ability to communicate using speech and hearing. People who are suffering from this use other media of communication such as sign language. Although sign language is ubiquitous and thus it remains a challenge for non-sign language speakers to speak with signing speakers or signers. With advances in deep learning and computer vision there was promising progress in the fields of motion and gesture recognition using deep learning and computer vision based techniques. The focus of this system is to create a vision based application which offers signing translation to text thus aiding communication between signers and non-signers. The proposed model takes video sequences and extracts temporal and spatial features from them. Then use Inception, a CNN for recognizing spatial features and then use a RNN to train on temporal features. The dataset used is the American Sign Language Dataset. The CNN and RNN model are trained independently. The data set of 600 training samples of 300 frames each are shuffled and split with an 80-20 split into test and validation data, which gives

54 samples for training and 6 for validation. Then evaluate the CNN and RNN independently using the same training and test samples for both. This ensures that the test data is not seen during training by either the CNN and the RNN. Both the models were trained to minimize loss by using cross-entropy cost function ADAM. The models are trained with 64 batch sizes and 10 epochs. Because the recordings are independent of each other, there is no continuation of gestures between two recordings. The gestures were restricted to 300 frames to ensure that all the crucial information was captured and wasn't excessive. The test data set was also augmented to double its size to gather more information from predictions about the model.

#### IV. PROPOSED SYSTEM

Using this system we paved a way for the mute person who can easily interact with normal person anywhere. Sign languages are the only way to communicate mute people with normal people. It is not easy for the impaired people to convey everything to normal people. So this system will solve this problem. One of the advantage of this system is that any other special equipment are not needed for this. Only a laptop is need. This system will be helpful in the areas like hospitals, ticket issuing counters etc. The impaired person just show the action before the webcam and the system produces voice as output. Each signs are assigned to each words as shown in Fig.4. In a language there will be connecting words like if, is, to etc. These words are also assigned to some signs as shown in Fig.5. Then we get a complete sentence as a result.



Fig. 4. Different Signs For Words.

Machine learning is an application of artificial intelligence (AI) which helps the systems to learn and improve from experience without being explicitly programmed. Machine learning aims on the development of computer programs that can examine data and use it learn for themselves. Deep learning ,it is the subset of machine learning . In artificial intelligence (AI) there are networks which was capable of learning unsupervised from data that is unstructured. It is known as deep neural network. Data set of different signs will



Fig. 5. Signs For Connecting Words.

be stored and trained. When the person start the video, the images will be captured and it will compare with the trained data. Then it identify the sign and convert to voice. OpenCV is a library for the programming functions. It is used for real time computer vision and for Image Processing. It can perform all the operation related to Images. Keras is a neural network library at the same time TensorFlow is the open source library. TensorFlow will come up with both high level and low level APIs while Keras give only high level APIs. Keras provides simple and consistent high level APIs and reduce the cognitive load for the users. Anyway TensorFlow and keras provide high-level APIs for building and training models with ease. Keras is more user-friendly because it was built in Python. A Convolutional neural network is a neural network which has one or more convolutional layers and are mainly used for segmentation, image processing, classification etc.

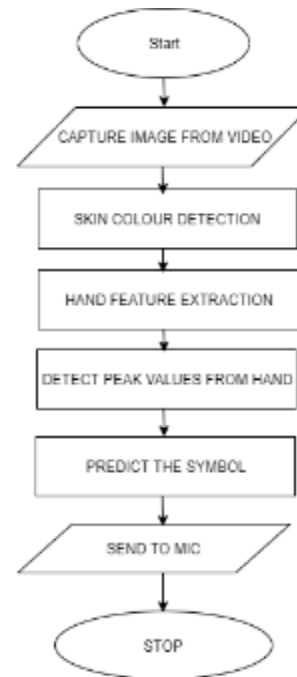


Fig.6. Flowchart

The core objective of this project is to recognizing the hand gestures and producing respective word as sound. Fig.6 shows the-flowchart of the system. User will start the video. Images will be captured from the video. The images captured from the camera are then stored in a testing dataset for further analysis. That frames will undergo skin colour detection. Skin color detection is the process of separation between skin and non-skin pixels and it is for identifying signs from the background. Then hand feature extraction take place. Softmax classifier is used here. To learn aligned gestural label from training process.After identifying the sign,sound will be send to mic. The block diagram of these process are shown in Fig.7.Capturing signs from real world and translating them is the main objective of this work.

There are many existing systems for this. The first system is Sign Language Converter this system is based on image processing using an Xbox 360 Kinect camera and sensor and a computer connected for processing [12]. Wearing gloves will not be comfortable for the user. The second system is the gesture vocalizer system using an ATMEGA16 as microcontroller for processing[14]. This system uses 4 flex sensors and an accelerometer in each hand for hand motion detection. A voice module and an LCD module is used for output. In these methods extra equipments are using. Speciality of our project over these existing methods are cost effective, easy to use,connecting words also can be represented. The third system is Image Processing Based Language Converter system using a computer webcam and a computer to convert RGB images to binary.The physically impaired person want to wear colored rings in his fingers [13].

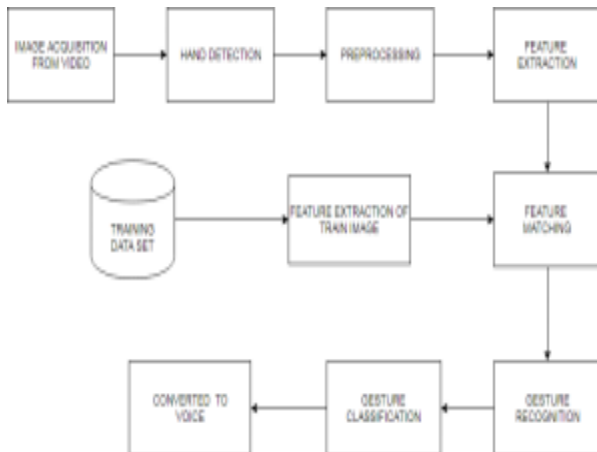


Fig. 7. A block visualization for the proposed system.



Fig. 10. word "you"



Fig. 8. Image In Data Set

Images of signs are stored as a grayscale images as shown in Fig.8. There will be a trackbar to adjust the brightness. Here for the whole images we placed the brightness as constant

level. When we show the sign before the webcam, it will identify the sign and it will be written below as shown in Fig.9. At the same time we can hear it as voice. In the dataset there will be 70 percentage images will be for training and 30 percentage for testing. Fig.10 shows the word "you".

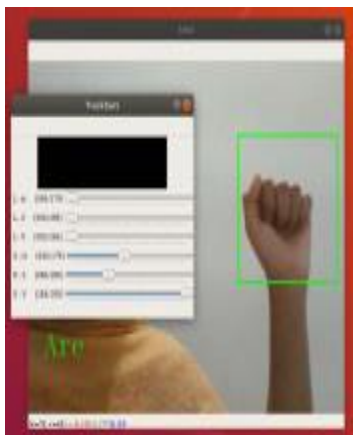


Fig. 9. Word "are"

## V. CONCLUSION AND FUTURE WORK

Sign language is a helpful to ease the communication between the mute or deaf community and additionally the standard people. Communication is the best media used by the people to communicate with each other. Dumb and Deaf people find a difficulty in communicating with normal people and therefore they cannot be fully part and effective personnel in their societies. This project aims to reduce the communication gap between the mute community and the standard world. That is this system is to improve the communication with the dumb people who are using any sign language to express themselves.

This is the useful innovation which is especially beneficial for mute people. By using this method, the communication gap between the normal people and the mute people can be reduced. This methodology interprets language into speech. The system overcomes the necessary time difficulties of dumb people and improves their manner. It's in addition useful for speech impaired and paralysed patient means those do not speak properly. In addition used for Intelligent Home Applications and industrial applications. Most of them do not meet the basic requirements. Some are very much complex, not user friendly and it's difficult for both side understand the application. Most of them don't provide the exact outcome what user wants. But in this system a webcam is captured the hand gesture from video and perform hand feature extraction. The image features are extracted a trained Convolutional Neural Network. Then predicted the respective symbol. Finally we got the result as voice. So that it would be audible to everyone. Here we are identified signs from live video. It is the main difference from other methods. This system is very helpful for the dumb people for expressing their proper communication and for opinions. This is leads to proper interaction between normal people and the dumb people.

The future works are about developing mobile application of such systems that enables everyone be able to speak

with dumb people. One of the area with the greatest potential impact is in the contribution that mobile application can reduce the communication gap between dumb and deaf people with normal people. In future we can implement an android based application for dumb people to communicate with normal people. Recently, communication through mobile phone is considered very essential in enhancing better understand in social situation. So there is a great opportunity for mankind in the communication sector of all over the world. That is Designing signs for more words, Designing application for support iOS these are the future work plans related to this one. All God creature has an importance in the society, recollecting this fact, let us try to include impaired people in our day to day life and live together.

### REFERENCES

- [1]. Gayathri, Dr.A. Sasi Kumar, "SIGN LANGUAGE RECOGNITION FOR DEAF AND DUMB PEOPLE USING ANDROID ENVIRONMENT", ISSN VOLUME-4, ISSUE-5, 2017;
- [2]. Suthagar S., K. S. Tamilselvan, P. Balakumar, B. Rajalakshmi, C. Roshini, "Translation of Sign Language for Deaf and Dumb People", International Journal of Recent Technology and Engineering (IJRTE) ISSN: 2277-3878, Volume-8 Issue-5, January 2020.
- [3]. Rajaganapathy. S, Aravind. B, Keerthana. B, Sivagami. M, "Conversation of Sign Language to Speech with Human Gestures", 2nd International Symposium on Big Data and Cloud Computing (ISBCC'15).
- [4]. Sachin Bhat, Amruthesh M, Ashik, Chidanand Das, Sujith, "Translating Indian Sign Language to text and voice messages using flex sensors", International Journal of Advanced Research in Computer and Communication Engineering Vol. 4, Issue 5, May 2015.
- [5]. Pooja Gupta, Dr. Ambuj Kumar Agrawal, Dr. Shahnaz Fatima, "Sign Language Problem And Solutions For Deaf And Dumb People", 3rd International Conference on System Modeling Advancement in Research Trends (SMART) College of Computing Sciences and Information Technology (CCSIT), Teerthanker Mahaveer University, Moradabad [2014].
- [6]. S.Philomina, M.Jasmin, "Hand Talk: Intelligent Sign Language Recognition for Deaf and Dumb", International Journal of Innovative Research in Science, Engineering and Technology (An ISO 3297: 2007 Certified Organization) Vol. 4, Issue 1, January 2015.  
Hussana Johar R.B, Priyanka A, Revathi Amrut M S, Suchitha K, Sumana K J, "Multiple Sign Language Translation into Voice Message", International Journal of Engineering and Innovative Technology (IJEIT) Volume 3, Issue 10, April 2014.
- [7]. Mahesh Kumar N B, "of Sign Language into Text", International Journal of Applied Engineering Research ISSN 0973-4562 Volume 13, Number 9 (2018).
- [8]. L. Jayatilake, C. Darshana, G. Indrajith, A. Madhuwantha and
- [9]. N. Ellepola, "Communication between Deaf-Dumb People and Normal People: Chat Assist", International Journal of Scientific and Research Publications, Volume 7, Issue 12, December 2017.
- [10]. Shadman Shahriar, Ashraf Siddiquee, Tanveerul Islam, Abesh Ghosh, Rajat Chakraborty, Asir Intisar Khan, Celia Shahnaz, Shaikh Anowarul Fattah, "Real-Time American Sign Language Recognition Using Skin Segmentation and Image Category Classification with Convolutional Neural Network and Deep Learning", Proceedings of TENCON 2018 - 2018 IEEE Region 10 Conference (Jeju, Korea, 28-31 October 2018).
- [11]. Kshitij Bantupalli, Ying Xie, "American Sign Language Recognition using Deep Learning and Computer Vision", 2018 IEEE International Conference on Big Data (Big Data).
- [12]. Taner Arsan, Oguz Ugen, "SIGN LANGUAGE CONVERTER", International Journal of Computer Science Engineering Survey (IJCSSES) Vol.6, August 2015.
- [13]. Koli P.B., Chaudhari Ashwini, Malkar Sonam, Pawale Kavita Tayde Amrapali, "Image Processing Based Language Converter for Deaf and Dumb People", IOSR Journal of Electronics and Communication Engineering, January 2016.
- [14]. K.V. Fale, Akshay Phalke, Pratik Chaudhari, Pradeep Jadhav
- [15]. "Smart Glove: Gesture Vocalizer for Deaf and Dumb People", Vol. 4, Issue April 2016.