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Sign Language Recognition Systems: A Review

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***Abstract*— The significant intention of this paper is to review some important issues related to the deaf people. These include Sign language, Sign language in India, Research work carried out in last twenty years and a brief comparison of major steps associated with the sign language recognition system. The survey examine vision based sign language recognition system in terms of i)Segmentation, ii)Feature extraction technique, iii) classifier/recognition technique, iv) Accuracy achieved and v) sign language considered, and glove based sign language recognition systems . This paper also highlights on strengths and limitations of sign language learning packages.**

Index Terms— ***Vision based sign language recognition, Glove based sign language recognition, Sign language learning packages.***

I. INTRODUCTION

Sign language is utilized by deaf people throughout the world as an essential method for communication. Sign is also used for communication by the people at a visible, but not audible distance. Sign language is the collection of postures, gestures, movement and facial expression. Posture refers to single image corresponding to a single command for example "Stop", where as sequence of posture is called gestures. They are also name as static (posture) and dynamic gesture (gesture). There are three basic hand forms to interpret the gestures. i)Hand shape with open and close finger position, ii) Hand position in the middle of forehead or in front of chest and iii) Hand movement in upward and downward direction.

II. SIGN LANGUAGE IN INDIA

India is second most populous country in world (estimated 1.29 billion plus population), so number of deaf people cannot be exactly estimated. According to the "Deafness Statics"[1] hearing loss is the third leading chronic disability found in India. Profound hearing disability in India is about one million out of which 1.2 million people with severe hearing disability, 0.9 million with moderate hearing loss and 7.1 million people with very mild hearing disability. Sign language is not uniform through the world it varies from nation to nation depending upon their respective national language. Specifically when we speak about India there is no shortage of language. Around 415 living languages, two official languages and 22 official scheduled language according to Ethnologus [2]. More than 1.5 million people in India uses Indian sign language for communication. But according to UNESCO report only 5% of deaf get education in India. Reason of such low literacy rate is may be because following factors: (a) People in India consider deafness as a punishment and signing is strictly discouraged (b) Deaf school rarely have any teacher who is fully signer.(c) Very less or we can say no higher education facility in India this is because no deaf school provide education beyond tenth standard.(d) Lack of research in Indian sign language. (e) Inefficient Indian sign language learning tools.

III. SIGN LANGUAGE RECOGNITION SYSTEM

With the advancement in human civilization, the development of sign language is the first step and development of human computer interaction is the second step. Lot of work has been carried out worldwide using artificial intelligence for different sign languages. The problem of sign language training and recognition system can be defined as the analysis of all the component of sign language and better understanding of sign or whole sequence of sign language communication. The automatic Sign Language Translation uses two basic approaches. First one is electronic data gloves having inbuilt sensors and second is visual approach in which a camera is used to capture images of signer & then image processing is carried out to perform recognition. Instrumented glove approach simplifies the recognition but complicates the hardware. Also it is expensive & less user friendly. On the other hand, vision-based approach is most suitable, user-friendly & affordable and it widely used but system development is based on placement and number of cameras, visibility of object i.e hand ,efficiency and effectiveness of algorithm used to extract the features, its results are also limited to presence of disturbance, background noise, surrounding furniture, clothing etc.

An ideal sign language recognition system is one which takes an input a sign language video and output a text interpretation of the sign language sentences. In order to achieve this goal there are number of research found in literature. The Table 1.1 described below highlight the various factors pertaining to vision based sign language recognition system. The work presented in Table 1.1 review number of researches on sign language system. A comparative study of different steps of recognition system will provide the direction for the work by the beginners in this area.

Table1.1 Literature Review of last 15 Years vision based approach.

Ref No	Background	Segmentation Technique	Feature Extraction Technique	Classifier/ Recognition	Accuracy	Sign Language Considered
4	Complex	Thresholding Skin Colour Edge detection	Fourier Descriptor Motion Analysis	HMM	85 to 90	20 **Simple Gesture** Human Computer Interface
5	Uniform	RGB TO Grayscale Canny edge detection	Hough Transform	Three Layer feed forward back - propagation Neural Network	92.3	15 signs of **American Sign Language**
6	Uniform	RGB Colour Thresholding	K mean Clustering Algorithm Manhattan Distance	Neural Network	99	24 Images of **Bengali Sign Language**
8 & 14	Uniform	RGB to B&W colour canny edge detection	Euclidean Distance between fingertip and wrist hand position	Thresholding	98.125	32 signs of **Tamil Sign Language** 12 Vowels 18 consonants.
9	No special background	Colour Segmentation of Colour Gloves	Zonal Coding to DCT (Discrete Cosine transform)	KNN and polynomial Classifier	87	Arabic Sign Language 12 commonly used words/phrases
10	(No Specific) Hand closer to camera	Blobs Otsus method Normalization	Shape descriptor 1.Cell occupancy feature. 2.Silhouette Feature	Back end classifier action graph	87.7	**ASL** 12 Dynamic ASL gesture.
11 & 39	Complex Background	HTS (Hand Tracking and Segmentation)	Hough Transform, Fourier Descriptor, Image Hu movement.	Genetic algorithm, window API		**Simple gesture** Human Computer Interface
15	Black uniform	Data Glove RGB to HIS colour space	FCM Clustering method	Recurring Neural network	95	**Arabic Sign language** 28 ArSl gestures
16	Uniform and no uniform	Skin colour Segmentation	VOP Video Object Plane Generation	Canny Edge point of successive VOP	99 for ASL 97.03 for British Sign language	**ASL** British Sign language.
17	Uniform	Grey to B&W conversion	Shape Descriptor (Solidity, Perimeter, Convex Area, Eccentricity, 9Major Axis	Proximal Support Vector Machine	91	40 static hand images with facial expression **Tamil Sign language**

			Length, Minor Axis length, orientation.)			
30	Uniform black background	RGB-Sensor	Configuration of hand movement orientation	SVM	80	34 **Brazilian Sign Language** gesture
32	Complex	Skin colour texture attributes multilayered perception (MLP) NN	Tchebichef orthogonal movement, geometric features.	KNN & SVM	94.67 in simple background 89.35 in complex background 96.88 with SVM classifier	30 **Arabic Sign language**
33	Complex Background, Constant Illumination ,Wear long Sleeved attire	Skin based segmentation. RGB HSV, YCbCr	Contour of head, right and left hand. Kalman Filter	SIFT	---	25 sign of **Indian Sign Language**
34	Uniform	Skin based segmentation and gesture trajectory estimation.	Binary hand sign extraction and model generation	MCC, CRF KNN Classifier	96.0 for isolated gesture and 88.9% for motion gesture	**Digits 0 to 9** Gesture based calculator HCI
35	Complex non uniform	YCrCb Colour Space single Gaussian model & Bayes Rule .	Radial Distance and Fourier Transform	Eucliden Distance	95.62	32 PSL (**Persian Sign Language)**
36	Non-uniform	Skin Colour based	Hue and saturation value of skin colour	Haar like feature based cascade Classifier & KNN Classifier	98.17 for Vowels 94.75 for Consonants	30 Alphabets and 6 vowels of **Bengali sign language**
37	Uniform background	Grey level thresholding RGB to YCrCb ,Otsu segmentation	Contours detection canny edge detection	Curvature Scale Space method	95.2	Single hand simple gesture **HCI**
38	Uniform Black	YCrCb Hue thresholding and RGB thresholding	Sobel Filter	Adaboost and SVM both tested	60 for Adaboost 80 for SVM	200 simple images, One handed. **HCI**
40	Cyber Gloves and magnetic tracker	Movement Epenthesis Segment and sub segment by Bayesian network	Two layer CRF and Full round robin procedure	SVM	89.9 to 95.7	**ASL s**entence (Pre stored word sign gesture) No alphabet and word formation.
41	Black background	RGB to HSV plane	Orientation Histogram and PCA	Correlation and Euclidean distance	82 to 93	**10 types of sentence**
42	Complex Background Kinect Depth Camera	Segmentation kinect tracking (Skeleton tracking and depth map from kinect)	SPEMD Super pixel earth mover distance.	Template matching, LpO(Leave-p-Out. CV(cross-validation)	For three different database. (99.1, 99.6, &75.8)	

43	Uniform Different Illumination	Otsu Thresholding	Hu's invariant movement	3 layer feed forward Neural Network	----	**Indian Sign Language** (ISL)
44	Video frame with uniform background	RGB to HSV plan Skin color filtering and histogram matching	Eigen value and Eigen vector are extracted from input video frame	Eigen value based weighted Euclidean Distance based classification	92.25	**Indian Sign Language** (ISL)
45	Black background, constant distance, constant Illumination		Morphological operation	Feed forward multilayered Neural Network	60	**Devnagari Sign language**
46	Static gesture Uniform background	Not specified (Jochen Triesch Dataset is used.)	DCT+PCA+PNN for Arabic And DWT+PCA+PNN for American Sign language	PNN (Probabilistic Neural Network)	80.2 for ArabicSL 94ASL	Arabic Sign language American Sign language
47	Uniform background with different lightening condition	RGB to grey and histogram equalization	Fast Fourier transform Binarization and Canny edge detection	Multilayer neural network with back propagation	84	Bosnian Sign Language
48	Uniform background	RGB to Grey	LPF and median filtering Morphological operation	multilayered Feed forward back propagation Neural Network	92	Arabic Sign language For number 0 to 9

IV. GLOVE BASED APPROACH

The glove based deaf-mute communication interpreter introduced by Anbarasi Rajamohan, Hemavathy R., Dhanalakshmi M [9]. The glove is internally equipped with five flex sensors, tactile sensors and accelerometer. The evaluation was carried out for ten beginners for letters 'A' 'B' 'C' 'D' 'F' 'I' 'L' O' 'M' 'N' 'T' 'S' 'W'. Word formation from letters is also performed using an end signal. The project can be enhanced to include two or more accelerometer's to capture the orientation of hand movements once the gesture is made. This will expand the capability to translate larger gestures.

Hand gesture recognition using MEMS[19] presents a wearable prototype model for Hand gesture recognition system which is capable of recognizing eight hand gesture, based on the signal from 3-axes MEMS accelerometer. This system is targeted mainly to help people with speech and hearing disabilities. The accelerations of a hand motion in three perpendicular directions are detected by accelerometers and acceleration values were transmitted to microcontroller. An automatic gesture recognition algorithm is developed to identify individual gestures in a sequence. Finally, the gesture is recognized by comparing the acceleration values with the stored templates.

Aneth K Rejina *et.al* [24]proposed an automatic American Sign Language recognition system using artificial neural network (ANN), it translate the ASL alphabets into text and sound. A glove circuit is designed with flex sensors, 3-axis accelerometer and sEMG sensors to capture the gestures. The finger bending data is obtained from the flex sensors on each finger whereas the accelerometer provides the trajectories of the hand motion. Some local features are extracted from the ASL alphabets which are then classified using neural network. The proposed system is evaluated for both user-dependent and user-independent conditions successfully for isolated ASL recognition.

The paper presented by Watcharin Tangsuksant *et.al* [28]gives the feasible method for American Sign Language recognition. The glove with 6 different color markers was designed. The markers are automatically detected using Circle Hough Transform. The 2D coordinate extracted from markers captured from two cameras are then used to extract 3D coordinate of marker using DLT. All possible triangle patches constructed from markers triplet are then computed and sorted in an orderly fashion. The areas sequences are then used as input of feed forward back propagation of Artificial Neural Network for feature classification. The experimental result illustrates the average of accuracy is 95 percent.

Cemil Oz and Ming C.Leu [29] proposed an ASL recognition system is being developed using ANN to translate ASL words into English. The System uses sensory glove called the cyber glove and a flock of bird 3-D motion tracker to extract the gesture. The data regarding finger joint angles obtained from strain gauges in the sensory glove define the hand shape. While data from tracker describe the trajectory of hand movements . The data from this device are processed by a velocity network with noise reduction and features are extracted for 50 ASL words.

V. SIGN LANGUAGE LEARNING PACKAGES

As compare to educational software packages available in the market worldwide, there are very few educational software specifically for sign language. These software packages usually come in the form of CD-ROM and some are accessible from internet. Following are some of sign language learning packages available.

ASLLA-Dictionary : This is an electronic dictionary. Use it to look up words in ASL and other languages. ASLLA-Fingerspell program loads random words then finger spells them. Helping beginners get used to seeing finger spelling. This program is built on Simple Direct Media Layer (SDL) and Paragui. These are cross platform libraries. The program work anywhere in Linux/unix/OSX, Windows, BeOs, and MacOs. These programs are licensed under the Gnu Public License (GPL). ASLLA is difficult to use and not user friendly, difficult to navigate .Speed control of signs, video clips and rotation of image is not available.

ASL SLanT: This application allows the user to read finger-spelled words that are randomly displayed from its built-in, user-customizable dictionary. The speed of spelling is controlled with a scrolling timer. The program also lets you enter words to be finger-spelled on the fly. A game is included as an added exercise. The game tests your finger-spelling speed. But Sign are limited and rotation of image is not available.

American Sign Language for kids: It is created for 3 years and above children. It also include games to enhance learning. But Graphics are amateurish and seem to have been drawn with Microsoft paint. It is difficult to learn because speech is not synchronized with signs.

Personal Communicator CD-ROM: PCCD-ROM is developed by Tech.Lab. at Michigan state, U.S.A. 2500 digital video signs and 4500 English words dictionary allows user to search for words and meaning. It is easy to use and navigate. But Rotation of Image is not available.

Survival Sign Language Vocabulary: It can be integrated with digital movie clip, searches sign by index. It also allows creating their own American sign. Speed control of signs is available to help in learning. Rotation of Image is not available also no exercise or quiz to enhance learning.

Webster Millennium ASL learning System: It teaches finger spelling and numbers, sign are simple to learn. It includes basic alphanumeric signs, words and sign writing. But it's not user friendly, difficult to navigate and limited number of words. It is not compatible with windows XP platform.

CONCLUSION

Many researchers tend to form a gesture sign for words that may have noticeable research outcome. In general, the researcher pave there research blueprint in four steps data acquisition, pre-processing, feature extraction, and sign recognition. However, in the case of alphabetic sign gesture prediction many researchers fails to conclude their research with significant outcome. To make a Sign Language that becomes universal, the scientists from different sign language need to cooperate. Distinguish the most common signs that are utilized and to construct an interesting Sign Language that ends up noticeably all-inclusive. It ought to cover all signs and some more signs should be included with the goal that it can cover all the sign which can be utilized as a part of that specific local of the deaf people. In the event that this progresses toward becoming reality then there is no need of a few mediators or some other help to communicate with different partners of the deaf.

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