Review on Feature Extraction methods of Image based Sign Language Recognition system

Hemina Bhavsar
Assistant Professor
S.S.Agrawal Institute of Computer Science,
Gujarat Technological University
Chandkheda, Ahmedabad, Gujarat
hemina.bhavsar@gmail.com

Dr. Jeegar Trivedi
Assistant Professor
Department of Computer Science & Technology,
Sardar Patel University
Anand,Gujarat
jeegar.trivedi@gmail.com

ABSTRACT

Sign language is the way of communication among the Deaf-Dumb people by performing hand gestures. This paper is present review on Sign language Recognition approaches that aims to provide communication way for Deaf and Dumb Community over Society. Basically There are main two approaches for sign language recognition is Sensor based and Image based. This paper describes review of Image based sign language recognition system. Signs are in the form of hand gestures and these gestures are identified from images as well as videos. Hand gestures are identified and classified according to features of Gesture image. Features are like shape, rotation, angle, pixels, hand movement etc. Features are finding by various Features Extraction methods and classified by Artificial Intelligence methods. The most significance of this paper is to review the key finding of the comparison of feature extraction methods of similar systems used in Image based hand gesture recognition on the base of accuracy rate.

KEYWORDS

Sign Language Recognition, , Feature Extraction, Support Vector Machine, Neural Network.

1. INTRODUCTION

Sign languages (SL) are known as Deaf and Dumb languages. SLs are gestural languages which uses sign message for communication by hand without speaking. Sign language varies from country to country with its own vocabulary and grammar. Even within one country, sign language can vary from region to region like spoken languages. Indian Sign Language (ISL) is a language used by Indian deaf and dumb community [1].There arises the need for sign language interpreters who can interpret sign language to spoken language and vice versa. But, the availability of such interpreters is limited, expensive and does not work throughout the life period of a deaf person. This resulted in the development of automatic sign language recognition systems which could automatically translate the signs into corresponding text or voice without the help of sign language interpreters [3]. Effective Sign Language Recognition system gives the chance to deaf people to express their idea without human translator.Sign Language translator To have an interaction with computer, vision based system is more suitable than traditional data glove based system, as sensors are attached to the

data glove and data suit where, user has to wear these cumbersome devices [2].This paper focuses on a study of sign language interpretation system with reference to vision based hand gesture recognition.

2. SIGN ACQUIRING METHODS

2.1 LEAP MOTION:

Leap Motion controller (figure 1) is a sensor which detects the hand movement and converts that signal into computer commands. It consists of two IR cameras and three infrared LED's. LED generates IR light signal and camera generates 300 frames per second of reflected data. These signals are sending to the computer through USB cable for further processing[3].

2.2 KINECT SENSOR:

Kinect is Microsoft motion sensor with Xbox 360 gaming console shown in figure 2.it consist of RGB camera , depth sensor and multi-array microphone. It recognizes facial movement and speech [4].

2.3 DATA GLOVE:

This method uses different sensor to detect hand gesture signal. Hand gesture signal is in the form of analog. ADC is used to convert analog signal into digital form. It consists of flex sensor and accelerometer. Flex sensor is used to detect bend signal[5].

2.4 VISION BASED:

In this method web camera used to capture images. After that, image segmentation has done. Feature like palm, finger extracted from input image. Different hand motion that is half closed, fully closed, semi closed was detected. Data is saved in vector and that vector is used for recognition of alphabets [6].

3. METHODOLOGY OF SIGN LANGUAGE RECOGNITION

3.1 IMAGE PROCESSING :

Image processing is a method to convert an image into digital form and perform some operations on it, in order to get an enhanced image or to extract some useful information from it. It is a type of signal dispensation in which input is image, like video frame or photograph and output may be image or characteristics associated with that image.

3.2 PURPOSE OF IMAGE PROCESSING :

The purpose of image processing is divided into 5 groups. They are:

1. Visualization - Observe the objects that are not visible.
2. Image sharpening and restoration - To create a better image.
3. Image retrieval - Seek for the image of interest.
4. Measurement of pattern – Measures various objects in an image.
5. Image Recognition – Distinguish the objects in an image.

In Sign Language Recognition Image processing is used to better extract features from input images. Images are in static image or dynamic image of sign perform by human. In particular, the features that we extract from sign or hand gesture images should be invariant to background data, translation, scale, shape, rotation, angle, coordinates, movements etc.

a. First, images are converted to grayscale from colored.
b. Since the background data is not tested, it should be remove the background from the foreground. By subtracting the background image from an input image.
c. Next step is apply threshold technique to ensure that hand pixels would not be subtracted out, and it will be converted to binary image.
d. Then crop the target part and evaluate various morphological features from image using various feature extraction algorithms.

3.3 SYSTEM ARCHITECTURE:

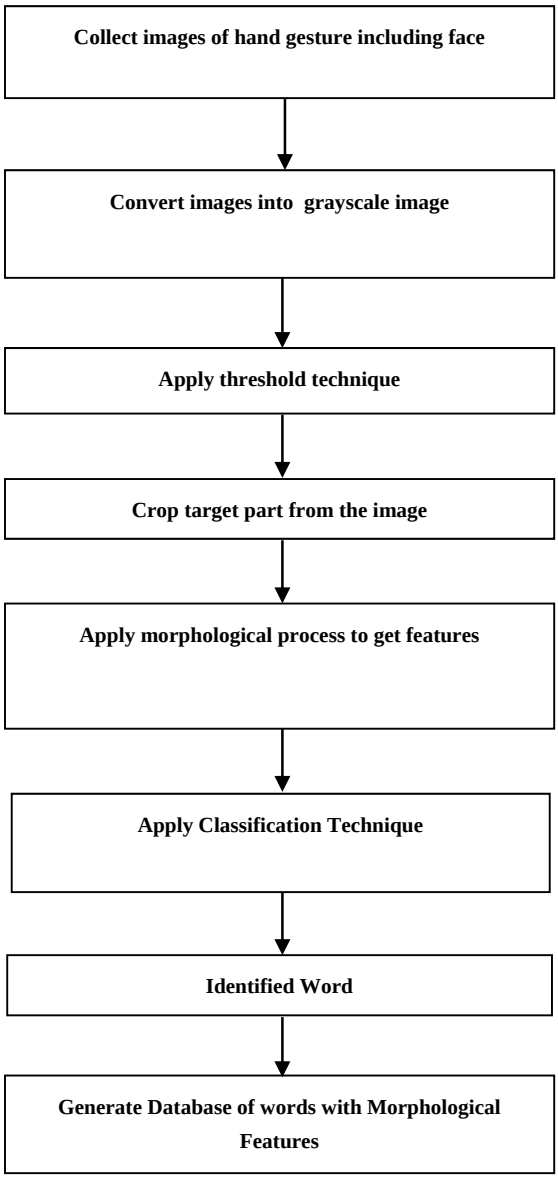

Fig-1 : Find morphological features from Image and generate Training Database

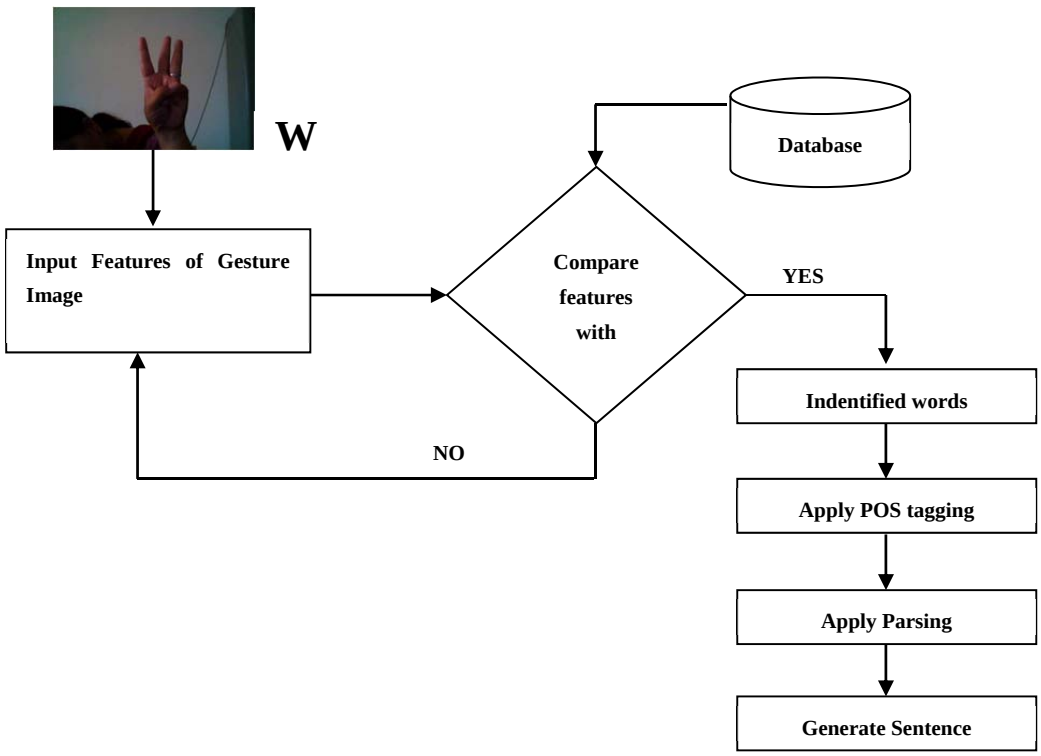

Fig-2 : Find morphological features from Image and Compare with Training Database

4. LITERATURE REVIEW

M. V. D. Prasad, P. V. V. Kishore, E. Kiran Kumar, D. Anil Kumar [7] presented methods for Indian Sign Language Recognition. wavelet based fusion of two weak edge detection models. One is morphological subtraction model and the other is gradient based canny edge operator. Elliptical Fourier descriptors provide shape models used with optimized number of shape descriptors. Principle components determined find the feature vector to a minimum to accommodate all the frames in the video sequence. Classification of the signs is done by Back Propagation Neural Network Algorithm. The recognition rate stands at 92.34%.

Suriya M. , Sathyapriya N. ,Srinithi M. ,Yesodha V, [8] this four persons presented system that recognizing sign language of 26 hand gestures in Indian sign language using MAT LAB. 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 Linear Discriminant Analysis (LDA) algorithm was used for gesture recognition and recognized gesture is converted into text.

Amitkumar Shinde, Ramesh Kagalkar [9] provide a system includes efficient and robust hand segmentation and tracking algorithm to recognize 43 isolated words from the Standard Marathi sign language. In their system they recognize some very basic elements of sign language and to translate them to text and vice versa in Marathi language. The different images were tested and result found that new technique of classification gives 90% accuracy.

Parul Hardeep et al. [10] provide method for recognize sign language. It has three steps: 1. Pre-processing: First input sign image in RGB to convert into Lab colour space where L is lightness a and b are two colour channel. 2. Feature Extraction: It was done using Area, height, Euclidance distance, Average height. 3. Classification: Feed forward back propagation algorithm was used for training and classification. It was provide 85% accuracy.

Druva N. et al. [11] explored the various possible ways of segmentation using different color spaces and models and presents with highest accuracy. In this paper authors compare RGB, Y'CbCr and HSI color spaces. Images obtained from the camera obtained in RGB color spaces. RGB color space is primary color space since it primary colors red, green and blue as its color components. In digital photography is Y'CbCr color space which contain Y' or luma component which describe brightness, Cb is describe blue difference chroma and Cr is describe red difference chroma component. H or Hue describes primary color, S or Saturation describes as total amount of color and I or Intensity is described total amount of light intensity. Clearly seen

from authors result that HSI model would greatly benefit in order to segment the hand and fingers. Future work include robust video processing algorithm to identify various gesture and keep memory of database minimal.

Andres Jess´e Porfirio, Kelly La´ıs Wiggers, Luiz E. S. Oliveira, Daniel Weingaertner [12] , presents a method for recognizing hand configurations of the Brazilian sign language (LIBRAS) using 3D meshes and 2D projections of the hand. Videos were manually segmented to extract one frame with a frontal and one with a lateral view of the hand. For each frame pair, a 3D mesh of the hand was constructed using the Shape from Silhouette method, and the rotation, translation and scale invariant Spherical Harmonics method was used to extract features for classification. A Support Vector Machine (SVM) achieved a correct classification.

Hanning et al. [13] presented hand gesture recognition system based on local orientation histogram feature distribution model. Skin color based segmentation algorithms were used to find a mask for the hand region, where the input RGB image converted into HSI color space. To compact features representation, k-means clustering has been applied. This system was based on static hand gesture and time consuming.

Nasser H. Dardas et al. [14] presented real time system which including detecting and tracking hand in cluttered background using skin detection and contour comparison algorithm after face detection and subtraction and recognition using principle Experiments show that system could achieve satisfactory real time performance as well as classification accuracy above 90% under variable space, orientation, and cluttered background.

Keskin [15] performed the recognition of ASL hand configurations of the 10 digits with videos acquired using Kinect. The method is based on obtaining a 3D skeleton of the hand which, combined with 21 segmented hand parts, form the feature vector. The classifier used in the experiment the SVM had results with an accuracy rate of 99.9%.

El-Bendary et al. [16] developed an Arabic alphabet signs translator with an accuracy of up to 91.3%. Videos are taken of deaf people which convert into text. The features used are rotation, scale and translation invariant. Videos are converted into Frames. For each frame, the distances between three different black pixels are used to construct the feature vector. In the recognition stage, a multilayer Perceptron (MLP) neural network and a minimum distance classifier (MDC) are used.

Quan [17] described hand signals based on spatial and temporal information extracted from video sequences. The database consisted of 30 letters of the Chinese alphabet, with 195 images representing each letter, totaling 5850 images. Color histogram, Hu moments, Gabor filters and Fourier descriptors were used as input features. Support Vector Machine (SVM) used as classifier, and hit rates were 95.55%.

Advanced Marathi Sign Language Recognition using Computer Vision For the recognition of the sign language a touch screen based approach is developed in [18].

The author tries to recognize the character generated from the screen sensor and transform to speech signal based on a recognition algorithm.In an approach [19] the author suggests in recognizing the hand gesture based on the finger boundary tracing and fingertip detection.

The author suggested to Identify the American Sign Language based on the hand gesture passed.In [20], Mohandes introduced an automatic recognition of the Arabic sign language letters. Support vector machines were used for classification and moment invariants are used in feature selection. A recognition rate of 87% was achieved.

AlJarrahand Halawani [21] developed a neuro-fuzzy system that deals with images of bare hand signs and achieved arecognition rate of 93.55%.

In [22], Al-Rousan and Hussain built an adaptive neurofuzzy interference system for letter recognition. A coloured glove was used to ease the process of segmenting the hands region. The recognition accuracy achieved was 95.5%.

Jason Isaacs and Simon Foo [23] describes system that recognizing 2D hand poses for application in video-based human-computer interfaces. They have developed a *two* layer feed-forward neural network that recognizes the 24 static letters in the American Sign Language (ASL) alphabet using images. T*wo* wavelet-based decomposition methods have been used. The first produces an *8*- element real-valued feature vector and the second a 18-element feature vector. Each set of feature vectors is used to train a feed-forward neural. The system is capable of recognizing instmces of static ASL finger spelling with *99.9%* accuracy.

Table 1. Comparison of Feature Extraction Methods

References	Research based systems	Feature Extraction Techniques	Input Source	Output	Features founded	Accuracy
24.	American Sign language	combines K curvature and convex hull algorithms	Images	Alphabets and Numbers	fingertip finder, eccentricity, elongatedness, pixel segmentation and rotation	94.32%
25.	Brazilian Sign Language	Lighting Normalization	Kinect sensor	LIBRAS alphabet	Euclidian distance	89%
26.	Arabic Sign Language	Fisher Linear Discriminant analysis	Microsoft Kinect sensor	20 Arabic language words	Dimension Measures	99.8%.
27.	Thai Sign Language	histograms of oriented gradients	Microsoft Kinect sensor at 0.8 - 1.2 meter distance	16 Hand Gestures	Dimension Measures	83.33%
28.	Dynamic Gesture Recognition	skeleton 3D trajectory for Key frame detection and Histograms of Cumulative Magnitudes for future extraction	Microsoft Kinect sensor	LIBRAS dataset	Global Features Like Structural Movements and Local Features like Position, Hand Configuration	Avarge 94%
29.	American Sign images	Canny edge detection, seeded region growing ,Speeded Up Robust Features (SURF) algorithm,	Video Camera	16 Alphabets	rotation, scaling, occlusion and variation	97.13%.
30.	Real-time static Alphabet American Sign Language Recognizer	Edge Orientation Histogram (EOH)	Images	Alphabets A to Z	Pixel Regions, Area	88.26%
31.	Indian Sign Language Translator	2D FFT Fourier Descriptors	Images	10 numbers, 26 alphabets and 10 different phrases.	External Boundary Points	Alphabets:85.73% ,Numbers:95.5% ,Phreses:97.5%
32.	Sign Language Recognition	Elliptical Fourier Descriptors	Images by 4-Camera Model	Alphabets A to Z, Numbers	Hand shapes	95.10%

References	Research based systems	Feature Extraction Techniques	Input Source	Output	Features founded	Accuracy
33.	Real Time Hand Gesture Recognition System for Android Devices	Color-Based Segmentation, Smoothing	Images from Smart Phone	0-9 Numbers	convex points in contour, point furthest away from each convex vertex	93%
34.	Bengali Sign Language Recognition	Gaussian Smoothing, Canny Edge Detector	Images	18 Bengali Words	Contours	90.11%

35.	Indian Sign Language Recognition	Fourier Descriptors	Images	Alphabets	shape (scale, rotational and translational invariance)	96.15%
36.	ASL Number Recognition	Image Thinning, Count distance between fingers	Static Images	Numbers	Distance between Fingers	92.09%
37.	Indian Sign Language Recognition using Transform Features	Hybrid Wavelet Transform	Images	Alphabets	Fractional Coefficients	91.02%
38.	Indian Sign Language Recognition System under Complex Background	Frame Differencing, Contour Matching algorithm, Calculation of centroids	Video	10 English Words	global transformations, zones and geometric features	One Hand: 90.0%, Two hand:86.0%
39.	Sign Language Interpretation	* Blob Analysis, Noise reduction using smooth Gaussian filter, * Histogram equalization is performed in order to adjust and normalize brightness and contrast of processing frame, * Image scaling is done to reduce the computational effort	Video	English Sentence	hand shape, size and color and different lightening condition in various angles	92.68%
40.	Chinese Sign Language Recognition	9-dimensional feature vector	Kinect	20 signs	Location feature, Spherical coordinate feature	69.32%
41.	Sign Language Recognition	* Contour is achieved through Euler-Largrange equation, * Frame average based pooling factions	Video	17 Sign words	Intensity, Boundary, Shape Information	93.7%
42.	American Sign Language Detection System	* HSV Color Model * Edge Detection, * Principal component analysis (PCA) for dimension reduction,	Images	Alphabets	hand shape, size and color	65%
43.	American Sign Language Detection System	* gradient magnitude features, * Random Projection (RP) and Kernel Principal Component Analysis (KPCA)	Static Images		hand shape, size and color	99.8%.

Table 2. Comparison of Feature Extraction Methods

Table 3. Comparison of Feature Extraction Methods

References	Research based systems	Feature Extraction Techniques	Input Source	Output	Features founded	Accuracy
44.	Real-Time Computer Vision-Based Bengali Sign Language Recognition	* Haar-like feature-based cascaded classifiers * Hue and Saturation value	Images	10 Bengali alphabet	Geometrical properties of the hand shapes	96%
45.	Sign Language Recognition	Principal Component Analysis(Matching Frames of Test image and Data Base image)	Video	10 Alphabets	Pixel Segmentation, Hand Sape	90%
46.	American Sign Language Recognition	3D Geometric Invariant Feature	Image	Alphabets	All feasible triangle area patches constructed from 3D coordinates triplet.	95%
47.	AUTOMATICSIGN LANGUAGEIDENTIFICATION	Hu-moments(for shapes),discrete grids (for locations), XORs (for movements)	Images	19 signers for British and Greek sign languages	Hand-shape, orientation, location and movement.	95%
48.	Static I donesian Sign Language Recognition System	contours	Images	Alphabets	Contours,ractangles, center points	62.6%,
49.	Persian Sign Language Recognition	* mean-shift (CAMSHIFT) algorithm for hand tracking, * radon transform and discrete cosine transform (DCT)	Video	20 dynamic signs	Angles	95.56%
50.	LIBRAS Sign Language Hand Configuration Recognition	* 3D meshes , * Silhouette method for shape, scale invariant Spherical ,Harmonics method for rotation, translation and scale	Video	61 Hand Configuration	shape (scale, rotational and translational invariance)	96%
51.	Recognizing Words in the Sign System for Indonesian Language	* Skeleton data features indicate the angle between human joints and Cartesian axes, * Color images are transformed to gray-scale and their features are extracted by using Discrete Cosine Transform (DCT) with Cross Correlation (CC) operation * depth features are extracted by running MATLAB region props function to get its region properties	Kinect	SIBI words	Angle, Shape, Depth	96,67%

Table 4. Comparison of Feature Extraction Methods

References	Research based systems	Feature Extraction Techniques	Input Source	Output	Features founded	Accuracy
52.	Recognizing and Classifying Indonesian Sign Language	Discrete Cosine Transform (DCT), Cross Correlation Function (With 5 frames)	Kinect camera	alphabet (A to Z) and numbers 1 to 10	Cross Correlation values between same rows or columns	97.22%
53.	Recognition of Indian Sign Language	shape descriptors, HOG descriptors (Histogram of Oriented Gradient) and SIFT (Scale Invariant Feature Transform)	Images	36 different signs	Eccentricity of an ellipse ,Aspect Ratio ,Compactness ,Solidity ,Orientation ,Spreadness , Roundness, local intensity gradients by HOG,A Number of key points/interest points using SIFT	93%
54.	LDCRFs-Based Hand Gesture Recognition	Polar systems	stereo color image sequences from video	alphabet characters (A - Z) and numbers (0 - 9)	location, orientation and velocity	96.14%
55.	Video Gestures Identification And Recognition Of Indian Sign Language	Fourier Descriptor	video	4 to 5 sentences, some words	shape signatures :centroid distance and complex coordinates (position function)	92.92%
56.	Indian Sign Language Recognition	Hu Moments and motion trajectory	video by Kinect	4 sign gestures of “A,” “B,” “C,” and “Hello.”	Hu Moments and motion trajectory	97.50%
57.	Sign Language Recognition	Sparse Observation (SO) description	RGB-D data captured by Kinect	20 categories of gesture	Motion Trajectory Feature	89% for HMM,82 % for DTW
58.	Static Hand Gesture Recognition of Persian Sign Numbers	Thinning Method	Images	Persian Sign Numbers	length of thin segments , end points of image	96.60%
59.	A Static Hand Gesture Recognition Algorithm	localized contour sequence (LCS) based feature	Images	Alphabets	Shape, Dimension, Edges	99.60%
60.	Real-time Ukrainian sign language recognition system	fingertips location and pseudo 2-dimentional image deformation model	videos	85 signs	Hand Shape	91.70%

5. CONCLUSION

In this review paper, different techniques of sign language recognition are reviewed on the basis of feature extraction. For sign acquiring methods, vision based future extraction methods are more reliable. We can easily find different features of sign like hand shape, rotation, angles, movements, coordinates, pixel intensity etc from images. It can be possible to make real time system which continuously capture sign generate sentences. According to this paper more research has been done on words, alphabets and numbers. In future it will go more in dimension on continues sentences of signs. Further review can be possible for image processing technique on the base of camera type, Image pixel resolution, frame compression, image background, Image Distance etc.

6. REFERENCES

[1] U. Zeshan, " 'A' level Introductory course in INDIAN SIGN LANGUAGE", Ali Yavar Jung National Institute for Hearing Handicapped, Mumbai, 2001, pp. 1-38.

[2] P. Garg, N. Agrawal, S. Sofat, "Vision based Hand Gesture Recognition", Proceedings of world Academy of Science, Engineering and Technology, Vol.37, 2009, pp. 1024-1029.

[3] Neelam K. Gilorkar, Manisha M. Ingle, "A Review On Feature Extraction For Indian And American Sign Language", Neelam K. Gilorkar Et Al, / (Ijcsit) International Journal Of Computer Science And Information Technologies, Vol. 5 (1) , 2014, 314-318.

[4] Manisha U. Kakde, Mahender G. Nakran, Amit M. Rawate, "A Review Paper on Sign Language Recognition System For Deaf And Dumb People using Image Processing", International Journal of Engineering Research & Technology (IJERT), ISSN: 2278-0181, Vol. 5 Issue 03, March-2016.

[5] Prakash B Gaikwad, Dr. V.K.Bairagi," Hand Gesture Recognition for Dumb People using Indian Sign Language" , International Journal of Advanced Research in computer Science and Software Engineering, pp:193-194, 2014.

[6] Shangeetha R K, Valliammai V, Padmavathi S.," Computer Vision Based Approach For Indian Sign Language Character Recognition", IEEE journoul on Information Technology, pp:181,2012.

[7] M. V. D. Prasad, P. V. V. Kishore, E. Kiran Kumar, D. Anil Kumar, "Indian Sign Language Recognition System Using New Fusion Based Edge Operator", Journal Of Theoretical And Applied Information Technology 30th June 2016. Vol.88. No.3, Issn: 1992-8645 Www.Jatit.Org E-Issn: 1817-3195.

[8] Suriya M. , Sathyapriya N. ,Srinithi M. ,Yesodha V., "Survey on Real Time Sign Language Recognition System: An LDA Approach", International Conference on Explorations and Innovations in Engineering & Technology (ICEIET - 2016), ISSN: 2348 – 8387.

[9] Amitkumar Shinde, Ramesh Kagalkar, "Advanced Marathi Sign Language Recognition using Computer Vision" , International Journal of Computer Applications (0975 – 8887) Volume 118 – No. 13, May 2015.

[10] Parul, Hardeep, Neural Network Based Static Sign Gesture Recognition System, International Journal Of Innovative Research In Computer And Communication Engineering (Ijircce), Vol. 2, Issue 2, Pg. 3066-3072, 2014.

[11] Dhruva N.; Sudhir Rao; RupanaguSachin; S.K., Sthuthi B.; Pavithra R.;Raghavendra, "Novel Segmentation Algorithm for Hand Gesture Recognition", IEEE, Vol.7,No.1,2013.

[12] Andres Jess´e Porfirio, Kelly La´ıs Wiggers, Luiz E. S. Oliveira, Daniel Weingaertner, "LIBRAS Sign Language Hand Configuration Recognition Based on 3D Meshes", 2013 IEEE International Conference on Systems, Man, and Cybernetics.

[13] Kishore, P. V. V., And P. Rajesh Kumar. "Segment, Track, Extract, Recognize And Convert Sign Language Videos To Voice/Text." *International Journal Of Advanced Computer Science And Applications(Ijacsa) Issn (Print)-2156* 5570 (2012).

[14] Nicolas D. Georganas And Nasser H. Dardas, "Real-Time Hand Gesture Detection And Recognition Using Bag-Of-Features And Support Vector Machine Techniques," Ieee Transaction On Instrumentation And Measurement, Vol. 60, No. 11, Nov 2011, Pp 3592-3607.

[15] C. Keskin, F. Kira, Y. E. Kara, and L. Akarun, "Real time hand pose estimation using depth sensors." in *ICCV Workshops*. IEEE, 2011, pp. 1228–1234.

[16] N. EI-Bendary, H. M. Zawbaa, M. S. Daoud, A. ella Hassanien, and K. Nakamatsu, "ArSLAT: Arabic Sign Language Alphabets Translator", in 2010 International Conference on Computer Information Systems and Industrial Management Applications (CISIM), 2010, pp590-595.

[17] Y. Quan, "Chinese sign language recognition based on video sequence appearance modeling," in Proc. 5th IEEE Conf. Industrial Electronics and Applications (ICIEA), 2010, pp. 1537–1542.

[18] Gaurav N. Pradhan, Chuanjun Li, Balakrishnan Prabhakaran, "Hand Gesture-based Computing for Hearing and Speech Impaired", IEEE Multimedia Magazine, Vol. 15, No. 2, pp. 20-27, April-June 2008.

[19] Aleemkhalid ,Ali M, M. Usman, S. Mumtaz, Yousuf "BolthayHaath – Paskistan sign Language Recgnition" CSIDC 2005.

[20] 20 Mohamed Mohandes, "Arabic Sign Language Recognition", presented at the International Conference on Imaging Sciences, Systems, and Technology, LasVegas,USA, 200l.

[21] O. AI-Jarrah and A. Halawani, "Recognition of gestures in Arabic sign language using neuro-fuzzy systems", Artif. Intell., vol 133, no 1-2, pp 117-138, 200l.

[22] M. A1-Rousan and M. Hussain, "Automatic recognition of Arabic sign language finger spelling.", Int. J Comput.Their Appl. Ijca, vol 8, pp 80-8, 2001.

[23] Jason Isaacs and Simon Foo, "Optimized Wavelet Hand Pose Estimation for American Sign Language Recognition", 2004 IEEE.

[24] Md. Mohiminul Islam,Sarah Siddiqua and Jawata Afnan," Real Time Hand Gesture Recognition Using Different Algorithms Based on American Sign Language ",978-1-5090-6004-7/2017 IEEE.

[25] Sérgio Bessa Carneiro, José O. Ferreira, Symone G. Soares Alcalá, Edson D. F. de M. Santos ,Talles M. de A. Barbosa," Static Gestures Recognition for Brazilian Sign Language with Kinect Sensor", 978-1-4799-8287-5/2016 IEEE.

[26] S. Aliyu, M. Mohandes, M. Deriche , S. Badran ,"Arabic Sign Language Recognition Using the Microsoft Kinect", 13th International multi conference on Systems, signals & devices, 978-1-5090-1291-6/ 2016 IEEE.

[27] Chana Chansri, Jakkree Srinonchat," Reliability and Accuracy of Thai Sign Language Recognition with Kinect Sensor", 978-1-4673-9749-0/2016 IEEE.

[28] Edwin Escobedo; Guillermo Camara," A new Approach for Dynamic Gesture Recognition using Skeleton Trajectory Representation and Histograms of Cumulative Magnitudes, 29th SIBGRAPI Conference on Graphics, Patterns and Images", 2377-5416/ 2016 IEEE.

[29] Cheok Ming Jin, Zaid Omar, Mohamed Hisham Jaward," A Mobile Application of American Sign Language Translation via Image Processing Algorithms", 2016 IEEE Region 10 Symposium (TENSYMP), Bali, Indonesia, 978-1-5090-0931-2.

[30] J ayshree R. Pansare, Maya Ingle," Vision-Based Approach for American Sign Language Recognition Using Edge Orientation Histogram", 2016 International Conference on Image, Vision and Computing, 978-1-5090-3755-1/ IEEE.
[31] Purva C. Badhe, Vaishali Kulkarni," Indian Sign Language Translator Using Gesture Recognition Algorithm", 2015 IEEE International Conference on Computer Graphics, Vision and Information Security (CGVIS)", 978-1-4673-7437-8.
[32] P.V.V.Kishore MIEEE, M.V.D.Prasad, Ch.Raghava Prasad, R.Rahul," 4-Camera Model for Sign Language Recognition Using Elliptical Fourier Descriptors and ANN", SPACES-2015, Dept of ECE, K L UNIVERSITY.
[33] Houssem Lahiani, Mohamed Elleuch, Monji Kherallah," Real Time Hand Gesture Recognition System for Android Devices", 978-1-4673-8709-5/20 15 IEEE.
[34] Muhammad Aminur Rahaman, Mahomood Jasim,Md. Haidar Ali, Md. Hasanuzzaman,"Computer Vision Based Bengali Sign Words Recognition Using Contour Analysis", 978-1-4673-9930-2/2015 IEEE.
[35] Pushkar Shuklai, Abhisha GargZ, Kshitij Sharma,Ankush Mittal," A DTW and Fourier Descriptor based approach for Indian Sign Language Recognition", 2015 Third International Conference on Image Infonnation Processing, 978-1-5090-0148-4/2015 IEEE.
[36] Asha Thalange, Dr.Shantanu Dixit," Effect of Thinning Extent on ASL Number Recognition Using Open-finger Distance Feature Measurement Technique", SPACES-2015, Dept of ECE, K L UNIVERSITY.
[37] Nalini Yadav, Sudeep Thepade, Pritam H. Patil," Noval Approach of Classification Based Indian Sign Language Recognition using Transform Features", 2015 International Conference on Information Processing (ICIP) Vishwakarma Institute of Technology. Dec 16-19, 2015.
[38] Ananya Choudhury, Anjan Kumar Talukdar and Kandarpa Kumar Sarma," A Conditional Random Field based Indian Sign Language Recognition System under Complex Background", 2014 Fourth International Conference on Communication Systems and Network Technologies, 978-1-4799-3070-8/2014 IEEE.
[39] Kanchan Dabre, Surekha Dholay," Machine Learning Model for Sign Language Interpretation using Webcam Images",978-1-4799-2494-3/2014 IEEE.
[40] ubo Geng, Xin Ma, Bingxia Xue, Hanbo Wu, Jason Gu, Yibin Li," Combining Features for Chinese Sign Language Recognition with Kinect", 2014 11th IEEE International Conference on Control & Automation (ICCA) June 18-20, 2014. Taichung, Taiwan.
[41] P.V.V.V Kishor, A.Kartheek,"Visual – Verbal Machine Interpreter for Sign Language Recognition under Versatile Video Backgrounds" ,978-1-4799-3486-7/2014 IEEE.
[42] A. Sharmila Konwar, B. Sagarika Borah, C. Dr.T.Tuithung ," An American Sign Language Detection System using HSV Color Model and Edge Detection ",International Conference on Communication and Signal Processing, April 3-5, 2014, India, 978-1-4799-3358-7/2014 IEEE .
[43] Mandar Kulkarni, Jitesh Butala ,Vishwas Udpikar," Mandar Kulkarni Jitesh Butala Vishwas Udpikar", 978-14799-3080-7/2014 IEEE.
[44] Muhammad Aminur Rahaman, Mahmood Jasim, Md. Haider Ali and Md. Hasanuzzaman," Real-Time Computer Vision-Based Bengali Sign Language Recognition", 2014 17th International Conference on Computer and Information Technology (ICCIT), 978-1-4799-6288-4/2014 IEEE.
[45] Ankita Saxena,Deepak Kumar Jain,Ananya Singhal," Sign Language Recognition Using Principal Component Analysis", 2014 Fourth International Conference on Communication Systems and Network Technologies, 978-1-4799-3070-8/ 2014 IEEE.
[46] Watcharin Tangsuksant, Suchin Adhan, Chuchart Pintavirooj," American Sign Language Recognition by Using 3D Geometric Invariant Feature and ANN Classification", The 2014 Biomedical Engineering International Conference (BMEiCON-2014), 978-1-4799-6801-5/2014 IEEE.
[47] Binyam Gebrekidan Gebre, Peter Wittenburg,Tom Heskes ," AUTOMATICSIGNLANGUAGEIDENTIFICATION", 978-1-4799-2341-0/2013 IEEE.
[48] Rudy Hartanto, Adhi Susanto, and P. Insap Santosa," Preliminary Design of Static Indonesian Sign Language Recognition System", 978-1-4799-0425-9/2013 IEEE.
[49] Hadis Madani, Manoochehr Nahvi," Isolated Dynamic Persian Sign Language Recognition Based On Camshift Algorithm and Radon Transform", 978-1-4673-6206-1/2013 IEEE.
[50] Andres Jess´e Porfirio, Kelly La´ıs Wiggers, Luiz E. S. Oliveira, Daniel Weingaertner," LIBRAS Sign Language Hand Configuration Recognition Based on 3D Meshes", 978-1-4799-0652-9/2013 IEEE.
[51] Erdefi Rakun, Mirna Andriani, I Wayan Wiprayoga, Ken Danniswara and Andros Tjandra," Combining Depth Image and Skeleton Data from Kinect for Recognizing Words in the Sign System for Indonesian Language (SIBI Sistem Isyarat Bahasa Indonesia)", ICACSIS 2013 ISBN: 978-979-1421-19-5/2013 IEEE.
[52] Erdefi Rakun, M. Febrian Rachmadi, Andros, Ken Danniswara," Spectral Domain Cross Correlation Function and Generalized Learning Vector Quantization for Recognizing and Classifying Indonesian Sign Language", ICACSIS 2012 ISBN: 978-979-1421-15-7.
[53] Subhash Chand Agrawal, Anand Singh Jalal, Charul Bhatnagar," Recognition of Indian Sign Language using Feature Fusion" IEEE Proceedings of 4th International Conference on Intelligent Human Computer Interaction, Kharagpur, India, December 27-29, 2012.
[54] Mahmoud Elmezain ,Ayoub Al-Hamadi ," LDCRFs-Based Hand Gesture Recognition", 2012 IEEE International Conference on Systems, Man, and Cybernetics October 14-17, 2012, COEX, Seoul, Korea, 978-1-4673-1714-6/2012 IEEE.
[55] ravin R.Futane , Dr. Rajiv V. Dharaskar ," Video Gestures Identification And Recognition Using Fourier Descriptor And General Fuzzy Minmax Neural Network For Subset Of Indian Sign Language", 525978-1-4673-5116-4/2012 IEEE.
[56] J. L. Rahejaa, A. Mishrab, and A. Chaudharyc," Indian Sign Language Recognition Using SVM", ISSN 10546618, Pattern Recognition and Image Analysis, 2016, Vol. 26, No. 2, pp. 434–441. © Pleiades Publishing, Ltd., 2016.
[57] Hanji Wang,Xiujuan Chai,Xlin chen,"Sparse Observation (SO) Alignment for Sign Language Recognition",0925-2312/2015 Elseiver.
[58] Alaa Barkoky, Nasrollah M. Charkari, "Static Hand Gesture Recognition of Persian Sign Numbers uses Thinning Method", 978-1-61284-774-0/2011 IEEE.
[59] Dipak Kumar Ghosh, Samit Ari," A Static Hand Gesture Recognition Algorithm Using K-Mean Based Radial Basis Function Neural Network", 978-1-4577-0031-6/2011 IEEE, ICICS.
[60] M.V. Davydov, I.V. Nikolski, V.V. Pasichnyk," Real-time Ukrainian sign language recognition system", 978-1-4244-6585-9/2010 IEEE.