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Sign Language Recognition using Hybrid Neural Networks

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Abstract*: Language has a prime role in communication between persons, in learning, in distribution of concepts and in preserving public contacts. The hearing-impaired have to challenge communication obstacles in a mostly hearing-capable culture. There are hundreds Sign Languages that are used all around the world today .The Sign Languages are established depending on the country and area of the deaf public. The aim of sign language recognition is to offer an effectual and correct tool to transcribe hand gesture into text. It can play a vital role in the communiqué between deaf and hearing society. Sign language recognition (SLR), as one of the significant research fields of human–computer interaction (HCI), has produced more and more interest in HCI society. Since, artificial neural networks are best suited for automated pattern recognition problems; they are used as a classification tool for this research. Back propagation is the most important algorithm for training neural networks. But, it easily gets trapped in local minima leading to inaccurate solutions. Therefore, some global search and optimization techniques were required to hybridize with artificial neural networks. One such technique is Genetic algorithms that imitate the principle of natural evolution. So, in this article, a hybrid intelligent system is proposed for sign language recognition in which artificial neural networks are merged with genetic algorithms. Results show that proposed hybrid model outperformed the existing back propagation based system.

Keywords* : *Hand Gesture; Sign Language Recognition; Artificial neural networks; Hybrid neural networks; Genetic algorithms.

I. INTRODUCTION

Sign languages are generally made for hearing impaired people, which can embrace translators, families, teachers, relatives and family members of hearing impaired people and the people who are tough of hearing themselves. To develop a sign language recognition system will assist the hearing impaired to talk more effortlessly with the normal people.

Earlier research in this field was based on Hidden Markov Model, which is a statistical model.

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With the advent of artificial intelligent algorithms, research in this field has seen But, now days, neural networks are used. Artificial Neural Networks with feed forward algorithm is used to compute the output for a definite input pattern and back propagation algorithm is used to train the networks [11].

Genetic algorithms work on the basis of natural selection. These belong to a big class of evolutionary algorithms. These are used to provide high rate results for optimization and search problems using bio inspired operation [1].

Genetic algorithms are several merits over back propagation algorithms like these are parallel in nature, more eligible for neural networks as it is capable of global searching and it deals with a population of points for neural networks so it is praiseworthy at global searching and it deals with a population of points rather than a single point. Furthermore, genetic algorithms drudge with a string coding of variables rather than the variables which needs only function values at separate points, a discrete function can be identified with no more burden[10].To overcome the problem of back propagation algorithm, the plan has been made to combine both back propagation and genetic algorithms. This type of attempt has not been made in the field of hand gesture yet.

The remaining paper is organized as follows: Section II provides the literature survey. Section III presents the Methods and materials. Section IV presents results and discussion. Finally, Section IV concludes the paper.

II. LITERATURE REVIEW

A number of contributions have done in the arena of hand gesture and sign language recognition. The brief survey has been provided in this section.

Tsang et al. presented a rapid and simple posture recognition method using fuzzy logic. The model comprised of three sub-models, namely, posture database, classifier and identifier. Firstly, classification was performed; afterwards, images were put into the database, and finally, actual comparison was performed by the identifier between input posture and the class they belonged to. Both, classification as well as identification, was accomplished using fuzzy logic so as to tackle uncertainty of data [4].

Holden et al. (2001) presented the hand tracker which includes 3D hand alignment with number of degree-of-freedoms (DOFs) from 2D image sequence with a color coded glove. Furthermore, the adaptive fuzzy expert system is applied for 22 signs with more than 95% results [5].

Chula et al. (2002) discussed the major challenges of Sign Language recognition system. In this research, a real-time application developed for Chinese Sign Language using 5100 gestures. A cyber glove and a 3D tracker is used to extract gestures based on geometrical analysis. The Gaussians and quick matching algorithms are introduced to improve the performance along with Hidden Markov Models (HMMs) [21].

Oz et al. (2005) proposed a system for ASL script and finger recognition for American Sign Language. It translated ASL into English. More than 95% accuracy has been achieved using a sensory glove and Flock of Birds 3-D motion tracker for real time recognition [11].

Nandy et al. (2011) described that Indian Sign Language contains of static and dynamic hand gestures for communiqué between mute community. Double handed movement based gestures have been used in this work. Furthermore, two different methods developed for recognition were Euclidean distance and K-nearest neighbor metrics [20].

Paulraj et al. (2011) et al. developed a SLR system using skin color segmentation and achieved recognition rate up to 93%. Furthermore, the interleaved 2D movement invariant feature extraction with neural networks has been proposed for the recognition [17].

Saraswat et al. (2012) arranged a huge video data base of ISL surrounded with some of the terminologies. Additional, automatic facial expression recognition system was proven to classify the expressions accomplished in these videos [8]. The same work was implemented using Turkish sign language data provided by Aran et al. [2] and a detailed evaluation was also provided between these two dataset.

Caridakis et al. (2012) presented work related combination of non-manual signs in automatic sign language recognition. Facial gestures, exactly, eye gaze, head pose, and some other facial expressions were debated in relation to their linguistic function. Computer vision matters associated to extracting facial features signs were offered and cataloging methods for integrating these non-manual cues into the overall Sign Language recognition architecture were presented [6].

Premaratne et al. (2013) presented a research which tried to implement recognition of ciphers using a processor using the static hand gesture recognition system established for customer electronics control at the University of Wollongong in Australia. The trial results showed that the numbers (0 to 9) can be correctly recognized with infrequent mistakes in few gestures. The system can be further improved to include larger cyphers using a dynamic gesture recognition system. AUSLAN, the Australian Sign Language was involved of numbers, finger spelling for words used in communal exercise and a medicinal phrasebook [15].

Pioug et al. (2015) proposed a recognition system using convolutional neural networks (CNNs) with aid of Microsoft Kinect, and GPU hastening. Instead of assembling complex handcrafted features, CNNs are capable to systematize the procedure of feature building. The system was capable to classify 20 Italian gestures with great correctness. The predictive classifier is able to generalize on users and backgrounds not happening through training with a cross-validation accuracy of up to 92% [13].

Kour et al. (2017) suggested feature detection and feature extraction of hand gesture with the aid of SURF algorithm using image processing. It is implemented to recognize 26 alphabets from A to Z. It is also claimed that it will provide better results for teaching and learning [22].

So, in this survey various sign languages using different classifiers are discussed. Different researchers took inputs through different equipment's like still cameras, Web Cameras, Microsoft Kinect etc. and it is also found that genetic algorithms are several merits over back propagation algorithms like these are parallel in nature. These are global search mechanisms with multidirectional and act with multiple population of points rather than single along with no extra burden[10].

To overcome the problem of back propagation algorithm efforts has been made to integrate both back propagation and genetic algorithm. No such attempt has been made in the field of hand gesture yet.

III. METHODS AND MATERIALS

The hybrid model comprised of five major phases: Data Formation, pre-processing, segmentation, feature extraction and classification, as shown in figure 1.

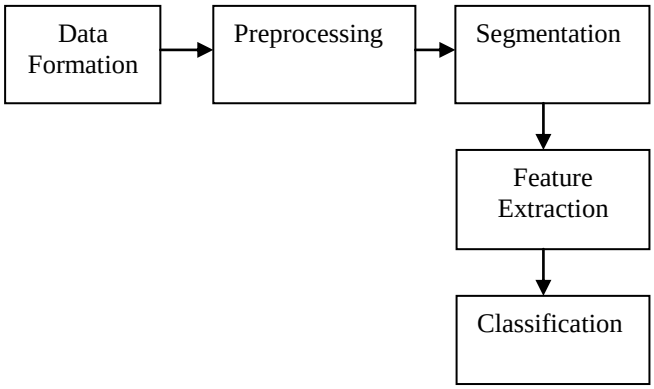


Fig. 1.Steps for Proposed Sign Language Recognition Model

A. Dataset Formation

The dataset comprising of 182 (26×7) images of twenty six alphabets (seven each) was collected from "Indian Sign Language Dictionary", released by Ramakrishna Mission Vidyalaya College of Education, Coimbatore in 2001 .[9][14] Samples were previously available in the form of videos. So, these videos were converted into still frames using window media player.

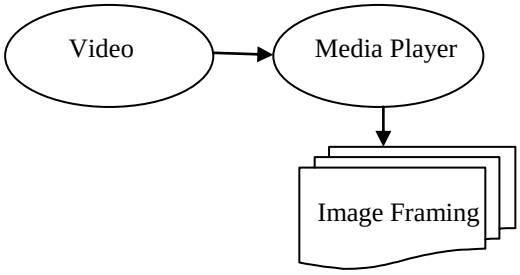


Fig. 2.Steps for Dataset Formation

B. Preprocessing

Pre-processing comprised of two operations: Resizing and Gray scale conversion. Firstly, the framed images were resized to a resolution of 128 × 128 pixels. Afterwards, the RGB images were converted into gray scale images for further computations.

C. Segmentation

In image processing discovery edge is essential problem because edge defines the borders of different objects. Edge can be defined as rapid or solid variation in the strength or we can say unexpected jump in intensity from one pixel to other pixel. By identifying the edge in any image we are just decreasing some amount of data but we are processing the shape.

For this the motive we used canny edge detection [12].Canny edge detection was introduced by John F. Canny (JFC) [3] in 1986. However, it is relatively ancient, it has become one of the regular edge detection methods and it is still used in investigation. The Canny edge detector focused on gray scale image.

In image processing finding edge is major issue because edge specifies the boundaries of dissimilar items in the image. The Canny edge detection algorithm is recognized as the optimum edge detector [18].

CANNY EDGE DETECTION (Canny 1983)

1. **Level the input image using Gaussian filter.**
2. **Calculate the gradient magnitude along with angle images.**
3. **Implement non-maxima suppression to the gradient magnitude image.**
4. **Use dual thresholding then connectivity study to distinguish and bond edges.**

Fig. 3.Canny Edge Detection

Feature Extraction

This is the most important part of recognition because the quality of recognition completely depends upon the features which classify one image from another. To developing a SLRS, it is essential to model shape (spatial characteristics) of the hand. [16].

The shape and geometrical based features are found to be most suitable for the recommended method. Here the shape signatures and their Fourier descriptors are used for feature extraction. In general, a shape signature is any 1-D function demonstrating 2-D areas or boundaries.

Following shape features are used in this research, the reason for picking these shape signatures is as they are frequently involved in recent FD executions and have been shown best for regular shape representation [14].

As discussed earlier, Canny Edge segmentation was performed to obtain the object of interest from the image. Thereafter, feature extraction was performed, on the basis of shape.

Ten shape based features were extracted: Area, Centroid, Major Axis, Minor Axis, Eccentricity, Orientation, Euler Number, Equal Diameter, Solidity, and Perimeter. The details of features are provided in table 1.

Table- I: Summary of Various Edge based Segmentation Techniques for Hand Gesture

Type	Feature	Description	Formula
Shape based Features	Area	Number of pixels in the region described by the shape	$Area = \sum_{x,y} I(x,y)$
	Centroid	f(x,y) = $\begin{cases} 1 & if\ (x,y) \in D \\ 0 & otherwise \end{cases}$ where D is the domain of binary shape	$\begin{cases} g_x = \frac{1}{N}\sum_{i=1}^{N} xi \\ g_y = \frac{1}{N}\sum_{i=1}^{N} yi \end{cases}$
	Major axis	Largest distance connecting one point to another on the region boundary, going through the center of the region.	---
	Minor axis	Smallest distance connecting one point to another on the region boundary, going through the center of the region.	---
	Eccentricity	Measure of aspect ratio	$Ecc = \frac{major\ axis}{minor\ axis}$
	Orientation	The angle between x-axis and the major axis and the major axis of the ellipse	------
	Euler Number	Relation between the no. of contiguous parts and the no. of holes on a shape	E=C-H
	Equi Diameter	Diameter of a round(circle) with similar area as the region	$ED = \frac{4.Area}{\Pi}$
	Solidity	Extent to which the shape is convex or concave	$Solidity = \frac{As}{H}$
	Perimeter	Distance around the boundary of object.	$Perimeter = \sum_{x,y} \lvert x_i - $

D. Classification

It is the phase where an image of hand gesture is categorized for recognition. The ANN approach tries to computerize the recognition process according to the way a person smears its intelligence in visualizing, analyzing, and lastly making a choice on the dignified acoustic features [20]. Moreover, here hybrid ANNs are used as classifier for Indian Sign Language recognition.

In artificial neural network three types of layers, the nodes have been involved in the network. First layer is called the input layer that takes specific no of values from the Input device. This layer does not do any dispensation and just passes the values further.

Second type of layers are called the hidden layers, which receipt the values from the first layer and implements the weights(values according to the priority) on them. This layer gives its output to the third layer. The layer is called the output layer, which incomes its input from the hidden layer and applies weights to the input values. Each node represents one gesture of the sign language. The values in output layer are considered as output.

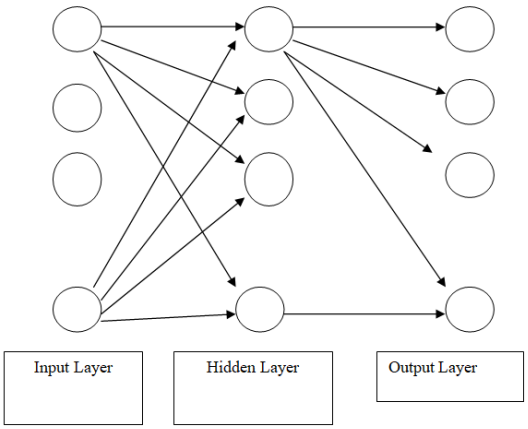


Fig. 4.ANN Architecture

- *Back Propagation Algorithm:* These suffer with scaling problem. Although these are suitable for simple problems but in complex cases these don't perform well and trap with local minima problems [19]. With the increase of hidden layers, the error rate goes up. So this research is an attempt to reduce this type of problems [7].
- *Genetic Algorithms:* In comparisons of back propagation algorithms, genetic algorithms are more proficient because these use global search techniques with multi directions and deal with population of points rather than single point [18]. Furthermore, these deal with a string coding of variable values rather that variables which needs function values at separate points. So these are faster than BP algorithms with low hardware cost. In other words, in the case of genetic algorithms, arithmetic operations are very simple and promising for implementation [10].
- *Hybrid Techniques:* So to resolve the problems of back propagation algorithm, attempts have been equipped to incorporate it with the genetic algorithms. In the field of hand gesture recognition, the research has been conducted for the hybridization of back propagation with the genetic algorithms using the above mentioned procedure.

The Proposed model contains five main steps. Firstly, gesture data based videos have been taken and converted into still images through framing at image acquisition level. Then then image processing techniques have been applied resize and conversion of the images from RGB to Gray. Then suitable segmentation techniques have been applied to separate out background from the image. After the segmentation with different techniques, these are evaluated subjectively and objectively. Then the features have extracted from the segmented images and reduced further to feed as input to the model. Finally recognition has been performed using hybrid computing model.

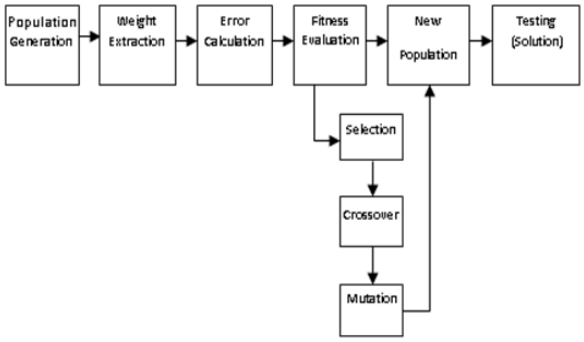


Fig. 5.The block diagram of BP/GA based Hybrid Classifier

IV. RESULTS AND DISCUSSIONS

An l-m-n architecture of 10-5-1 was used for simulation of neural networks as depicted in figure 5. The count of input neurons depends upon the number of feature extracted from the image, while the count of output neurons depend on the output values to be forecasted. For this scenario, the number of input neurons was 10 as the features extracted were 10 in count. Since, the network had shown minimum error values when number of hidden neurons were 5, so, m=5. Finally, the number of output neurons was taken as 1, because, there were twenty six classes (Class A, Class B and so on) and one of the twenty six will be forecasted as output class.

The GA/BP gesture recognition model worked in two fractions: Training and Testing. In the training phase, the 10-5-1 network was trained for inputs as well as outputs (supervised learning) to obtain weights. These weights along with different input values were then fed to the network for testing. In this study, inputs were hand gesture images and outputs were gestured like A,B,S and H From the total 182 images, 130 were used for training purposes while 52 images for testing.

A summary of various techniques applied at each step of the hand gesture model are provided in table II. Outputs of four samples corresponding to five phases are depicted in the last three columns of the table. While analyzing the outputs, the images acquired from natural scene are converted to gray scale images and then enhanced in pre-processing phase. Afterwards canny edge detection is used to obtain the hand object from images. The outputs are binary images. Canny Edge segmentation is well suited for edge detection purposes. Consequently, another segmentation technique: Sobel, Prewit and Robert edge operators were also applied.

Then, shape based features were obtained in the feature extraction phase. Shape based features were used to classify gestures according to size. Area, major axis, minor axis and eccentricity, all depicted the size of gestures and were computed using the Canny Edge segmented image. Perimeter feature was utilized to extract the size related information. Using these features, the GA/BP NN was trained in the classification phase for 130 different images. After training, weights were extracted, which were fed along with new 52 images so as to classify them according to the rule discussed earlier.

In this research, 7 samples for each character were used; out of which 5 were used for training while the rest 2 for testing. So the experiment was conducted on total of 182 samples. In this work, we compared four kinds of edge detection techniques with the Roberts's operator, Prewitt operator, Sobel operator and canny edge operator. Hence, it is proved that canny operator outperformed for edge detection and gesture recognition.

Table II: Summary of Various Edge based Segmentation Techniques for Hand Gesture

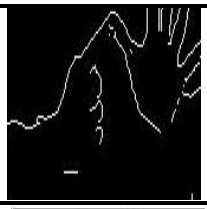
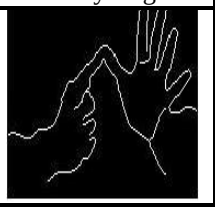
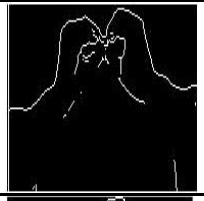
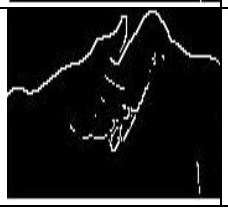
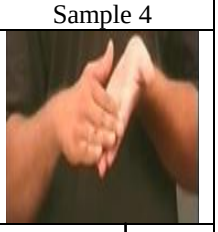
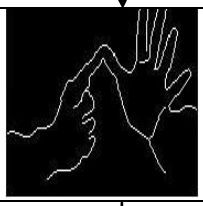
Sample	Gray Scale Image	Roberts	Prewit	Sobel	Canny Edge
A					
B					
S					
H					

Table III: Various Shape Based Features for Hand Gesture Recognition

Extracted Shape Features for different Gestures				
Shape based Features	**Features**			
	A	**B**	**S**	**H**
1. Area	149	68	76	55
2. Centroid	[56.5638 48.3020]	[2 35.5000]	[12.1842 38.8026]	[13.8182 28.1091]
3. Major Axis	144.6102	78.5196	83.7030	59.1683
4. Minor axis	28.6742	1.1547	13.0967	13.3692
5. Eccentricity	0.9801	0.9999	0.9877	0.9741
6. Orientation	41.3307	90	88.5420	82.0885
7. Euler Number	1	1	1	1
8. Equiv Diameter	13.7736	9.3049	9.8370	8.3683
9. Solidity	0.0655	1	0.1290	0.1385
10. Perimeter	348.1909	134	159.9411	116.2843

Table IV: Results with Proposed Model for Hand Gesture Recognition

Sr. no.	Phase	Technique Applied	Output of Phase			
			Sample 1	Sample 2	Sample 3	Sample 4
1.	Image Acquisition	ISL Dictionary				
2.	Pre-processing	Gray Scale Image				
3.	Segmentation	Canny Edge based method				
4.	Feature Extraction	Shape based features	as given in table no. III	as given in table no. III	as given in table no. III	as given in table no. III
5.	Classification	Genetic based Back propagation Technique	Gesture A	Gesture B	Gesture S	Gesture H

V. CONCLUSION

This article summarizes a broad relative analysis of enrichment based segmentation methods for sign language recognition. The authors have reached following conclusions:

- Sign language recognition demands the separation of extracted hand from the background image. The more correct the segmentation provides a better rate of classification. So for a good range of output enrichment of image is applied before the segmentation.
- Even, enhancement is relatively a crucial phase before segmentation but some proofs of their utilization exist in past work for sign language recognition systems.
- It was also observed in literature that gesture images were normally segmented on the basis of background , features and movements.
- A qualified review of four segmentation methods were performed: Robert, Prewit, Sobel, and Canny Edge.
- Results of 4-models were obtained for sign language recognition as shown in the table above.
- Canny edge detection is showing best results comparatively.
- To aid hearing impaired community, a hybrid model for hand gesture recognition is proposed, in this research article.

The model used hybrid model using artificial neural networks and genetic algorithms for recognition. All the results were obtained using Matlab R2013 tool on standard data base which is available at www.indiansignlanguage.org .Prior to image recognition step, edge detection was performed. Four kinds of edge detection methods including the canny operator, Prewitt operator, Sobel operator and Robert operator were used. It was analyzed that canny edge detector is the most suitable candidate for the hand gesture segmentation. In recognition phase, 7 samples for twenty six sign language characters were used; out of which 5 were used for training while the rest 2 for testing. So, the experiment was conducted on total of 182 samples.

It was found in the testing phase that the hybrid back propagation based genetic algorithm model outperformed the existing back propagation based hand gesture recognition. Hence, the model is proposed for future in the field of hand gesture and sign language recognition.

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