Proceedings of the 2017 4th International Conference on Advances in Electrical Engineering
28-30 September, 2017, Dhaka, Bangladesh

Hand Sign Language Recognition for Bangla Alphabet Based on Freeman Chain Code and ANN

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***Abstract*— Hand sign language recognition is one of the fundamental steps to overcome the barrier of communication between a deaf-mute and a normal person in the field of computer vision. In this paper, a hand sign language recognition framework is proposed for various Bangla alphabets using Artificial Neural Network (ANN). For that, initially the input image is normalized and the skin area is extracted on the basis of the YCbCr values corresponding to human skin color. The extracted area i.e., hand sign area is converted into a binary image and the gaps in the binary hand sign area are filled through the morphological operations. After that, the boundary edge of the hand sign area is extracted through the canny edge detector and extracts the hand sign region of interest (ROI). Finally, features are extracted from the hand sign ROI using Freeman Chain Code (FCC). The ANN is used for training and classifies the hand sign images. The proposed method is tested using various hand sign images and results are presented to demonstrate the efficiency and effectiveness.**

***Keywords*—Artificial Neural Network (ANN), Bangla sign language recognition, Freeman Chain Code (FCC), Skin color, YCbCr.**

I. INTRODUCTION

Sign languages are a non-vocal way of communication which includes physical movements of hands, fingers, arms, face, head or body in order to deliver information or message. The hand gesture is the most common way of communication between the deaf-mute and normal person.

The contact between a hearing impaired person and normal person have always been difficult. Incorporating them into the mainstream is very difficult as the majority of the society is unaccustomed with their language. Gesture recognition has become popular as the field of Human-Computer Interaction (HCI). A richer link can be created between humans and machines by sign gesture recognition than regular text interface [1] which has evolved to graphical interface using keyboard and mouse. In a word the use of gesture recognition is a vital issue in all the above resorts for both social purposes and purely individual goals. For this, researchers have been trying to develop different processes to recognize hand gestures automatically.

In this paper shows a process to recognize Bangla Hand Signs. Different technologies are used for acquiring gestures in recognition systems. The most common recent technologies include vision-based, instrumented glove, and colored markers approach.

In Vision Based Approaches the system only needs camera(s) and no other devices to collect the necessary images required for communication between the human and the computer. These approaches are usually user-friendly and easy to use; however, certain difficulties are involved such as conflicting background color, low camera pixel, the absence of adequate light [6], camera position [8] and other system requirements such as velocity, recognition time, robustness, and computational efficiency [9]. Also, capturing images using a webcam could be a little bit cumbersome and tedious [6].

Vision-based gesture recognition approach is used in most of the researchers as it is an easy, simpler, and natural method of communication between human and computer. This method is chosen in this paper. Two types of vision based approaches have been used by the researchers who have been working on Vision Based Bangla Sign Language Recognition System so far. One is Appearance-based approach and the other is 3D-Model based approach. The appearance-based approach is more naive. This approach deals with 2-Dimensional images which is less complicated than that of 3D. So, in this work, the Appearance-based approach is chosen.

Appearance-based approaches have two categories, (1) Motion-based systems: Use dynamic gestures, (2) Posture-Based Systems: use static hand gestures. Our system recognizes static hand gestures.

The aim of this paper is to develop a system for recognizing Bangla Sign Gestures to ease the difficulty of communication between the deaf-mute and normal people as well as to contribute in HCI.

II. RELATED WORK

In this section describes the related researcher works that have been done by the scientist and researcher in the previous time for hand sign recognition. Such as, In [2], authors proposed Linear Support Vector Machine (LSVM) classifier for their system to recognize the hand sign. The main theme of LSVM is to make a linear hyperplane that maximizes the between class scatter and minimizes within-class scatter. The system was able to translate a set of 27 signs to Bengali text with a recognition rate of

978-1-5386-0869-2/17/$31.00 ©2017 IEEE

96.46% in average. The proposed module gave better accuracy with respect to KNN classifier and Neural Network.

In [3], researchers present LSVM for recognition of Bangla signs of expressions and alphabets. For feature extraction, scale invariant feature transform (SIFT) was applied and then k-means clustering was executed on all the descriptors. Bag of words model was then introduced to this hybrid approach. Finally, a binary linear support vector machine (SVM) classifier was trained with a respective training data set. A respective recognition rate was obtained for the system.

A computer vision based Bengali sign words recognition system is proposed in [4] where contour analysis is presented. They have used Haar-like feature based cascaded classifier to locate the region of interest (ROI). After preprocessing, the system uses Canny edge detector to extract contours. The system uses Inter Correlation Function (ICF) to recognize sign words, based on the maximum similarity between tests and predefined training contour templates. The recognition rate achieved was 90.11%.

In [5] proposed a method for recognition of two-handed hand gestures using Linear Discriminate Analysis (LDA) and ANN. Neural Networks was used for training the dataset. The scheme used for training was back propagation with sum square error. On comparison, it was found that the Neural Network Classification worked extremely well for LDA algorithm features while it was not so good for the PCA features.

A Bangladeshi hand sign language recognizer (BdSLR) by employing Neural Network Ensemble (NNE) is proposed in [6]. BdSLR had been implemented involving different numbers of individual NNs in NCL. Feature extraction along with NCL algorithm was exploited to attain faster training and good recognition. The recognition rate achieved was approximately 93%.

A Real-Time Vision based Bengali Sign Language Recognition System was developed in [7]. K-Nearest Neighbor classifier was used in order to recognize gestures. The recognition rate for vowels was 98.17% and for Consonants was 94.75%, in average 96.46%.

In [8], authors research on Automatic Bangla Sign Language recognition where Artificial Neural Network (ANN) is used for training and classification. The vision-based approach was chosen for doing the research. Only isolated gestures were considered for the research. The system was given three different datasets. For the first case accuracy was 100%, for the second case accuracy was 96% and for the third case accuracy was 88%.

III. Proposed System

The proposed system consists of three main stages: (1) image acquisition and extract hand sign ROI, (2) feature extraction, and (3) sign recognition. The first stage is divided into five primary steps, i.e., 1) pre-processing, 2) RGB to YCbCr color conversion, 3) skin color conversion, 4) conversion to binary image and filled the gaps in the binary image, and 5) extract the boundary edge of the hand sign and detect the hand sign ROI. The flow diagram in Fig. 1 shows the steps implemented in the system.

A. Image Acquisition and Pre-Processing

The Bangla hand gesture alphabets image dataset is collected from [11]. From that dataset twenty samples are taken for each of the twenty signs. The hand sign images are shown in Fig. 2. The input image is first converted to the RGB image and resize into 250x250.

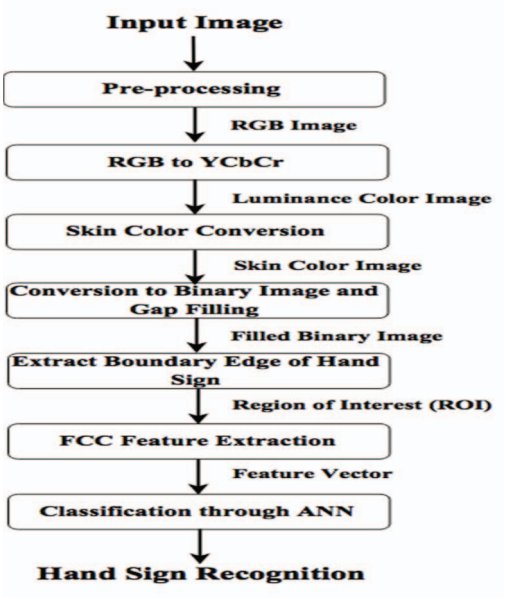


Fig. 1. Flow diagram of the proposed system.

Fig. 2. Input images for 20 signs.

B. RGB to YCbCr Color Conversion

Since RGB is more sensitive to illumination variations, the RGB images are converted into YCbCr. YCbCr color space is a linear luminance color space. In YCbCr, Y stands for luminance, Cb and Cr are the chromaticities of blue and red colors respectively. By this procedure, the RGB information is encoded. The information is range from 16 to 235 for Y and 16 to 240 for Cb and Cr. The RGB image is converted into YCbCr color space by utilizing the Eq. (1), (2), (3). The YCbCr image is shown in Fig. 3(a).

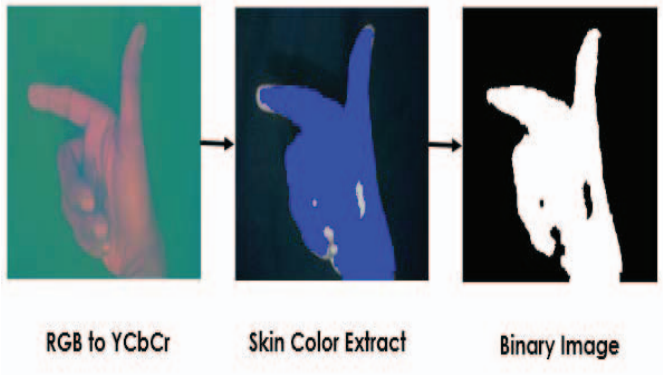
$$Y = 16 + (65.481 * R + 128.553 * G + 24.966 * B) \quad (1)$$

$$Cb = 128 + (-37.797 * R - 74.203 * G + 112 * B) \quad (2)$$

$$Cr = 128 + (112 * R + 93.786 * G + 18.214 * B) \quad (3)$$

C. Skin Color Conversion

After conversion to the YCbCr color space, the threshold value of Cb and Cr are needed to represent the skin color. The following values are chosen for the skin color detection that are, Cb >= 77 & Cb <= 127 and Cr >= 120 & Cr <= 173. The skin color image that is extracted from the above Cb and Cr values is shown in Fig. 3(b).



(a) (b) (c)

Fig. 3. Extraction Skin color and binary image: a) conversion to YCbCr image, b) skin color conversion, and c) conversion to binary image.

D. Conversion to Binary Image and Filled the Gaps

For getting the shape of the hand sign the skin color image is converted into a binary image. The binary image has only two colors, i.e. black and white for every pixel. The binary image is shown in Fig. 3(c). In Fig. 3(c), the there are exist some gaps in the binary image. To extract the appropriate shape of the hand sign the gaps should be filled up. For that, morphological operations such as dilation, erosion, and elimination of hole are used to fill the gaps in the binary image. The process is shown in Fig. 4.

E. Extract the Boundary Edge of the Hand Sign and Detect ROI

The filled binary image is resized to 70x70 pixels. Tiny regions less than 100 pixels are removed from the binary image. Then the edges of the binary image are detected using Canny edge detector as shown in Fig. 5.

Bounding box was created for a detected blob in the image and then the blob with the bounding box is cropped is shown in Fig. 6.

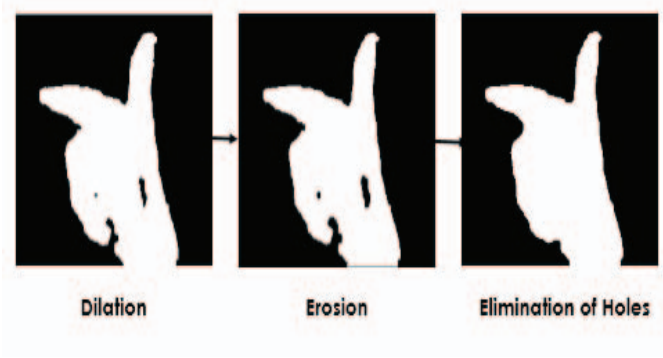
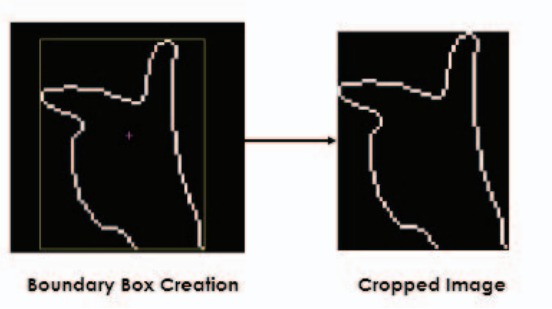


Fig. 4. Noise Removed Image

Fig. 5. Extract Canny edges for detecting hand sing boundary.



(a) (b)

Fig. 6. Cropped hand sign ROI: a) bounding box creation, and b) cropped image.

II. Feature Extraction

Feature extraction is a vital phase to find out the unique identity of a single hand sign. In the previous section, the hand sign ROI is extracted that is a boundary shape of the hand sign. In this respect, the features of the hand sign are extracted from the boundary shape. The boundary shape is connected sequence of a straight line in the specific direction and length. For extracting this type of features, the Freeman Chain Code (FCC) approach is used in this work. This is because of the Chain codes are one of the shape representations which are used to represent a boundary by a connected sequence of the straight line of specific direction and length.

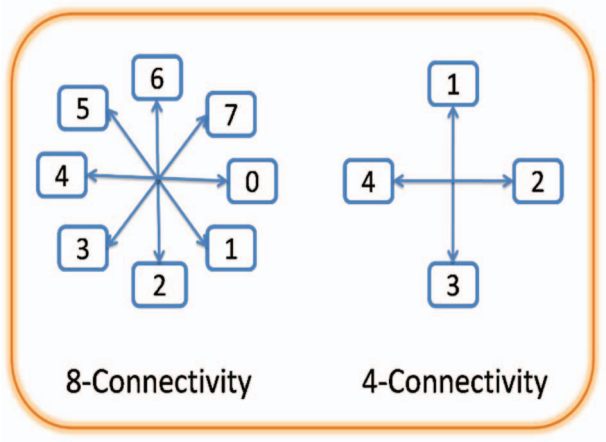


Fig. 7. Convention for Freeman Chain Code.

The Freeman introduces the chain code [10] to satisfy the aim of representing the specific boundaries or lines of shapes by the connected sequence of the straight line for particular direction and length. Basically, the chain code represents the two components, i.e., starting point of the shape or line coordinates, and the resulting chain code that represents the relative position of starting pixels and its followers.

The chain code is produced based on the connected pixels in the chaining direction in a specific boundary. Basically, the chain code is represented in two ways, i. e., 8- connected and 4-connected. This is based on the connectivity of the segments. To generate the chain code from the specific shapes or lines, the shape is divided according to the connected components. Finally, the connected components of the shape are established. The four and eight neighborhood pixels for the chain code is shown in Fig. 7.

For the proposed system, firstly, the boundary of the sign was traced by bwboundaries () to find out the 8-connectivity. Then the boundary values were given to the Freeman Chain Code. The frequency of each direction was calculated for every image. Then the frequencies of the 8 directions were stored in a matrix.

IV. Hand Sign Recognition

Artificial Neural Network was implemented for the training and classification process. Feed forward back propagation neural network was used. The extracted features were used as input data to train the network. Back propagation is a systematic method for training multiple layer artificial neural networks. It has a strong mathematical foundation. Backpropagation can be applied to the network with any number of hidden layers. The training objective is to adjust the weights so that the application of a set of inputs produced the desired output. To accomplish this, the network is usually trained with a large number of input-output pairs.

V. Result Evaluation

The experimental results of hand sign images are explained in this section. All experiments were performed on Intel(R) Core(TM) i3-3120M@2.5GHZ processor with 8GB RAM in the MATLAB environment. Here, used 20 hand gestures for training the network, 20 images per gesture, i.e., the training set contains 400 images (20x20). The testing set contains 200 images (20x10), 10 per sign.

Fig. 8. Sample example: Sample recognized image for alphabet ‘daw’.

The experiment was done to observe two things, the behavior, and the accuracy. The accuracy of the system is measured by testing various input patterns of hand gesture sign and observing the output of the system. Various test images were used for checking the accuracy of the system. The error term is presented as Sum-Squared Error (SSE). A sample recognized image is shown in Fig. 8. The recognition rate of each of the 20 Bangla sign alphabets is shown in Table I.

After calculating the recognition rate of all the alphabets, it is seen that the recognition system has a recognition rate of 96.5%. Comparison of this research work with other works is statistically analyzed by their recognition rate. This is illustrated in Fig. 9. The existing works procedures are explained in the related work section.

From the bar chart shown in the Fig. 9, it is revealed that the proposed system’s recognition rate is better than the existing methods. The reason behind this is the system effectively detects the boundaries of the hand sign and efficiently extracts the features through the Freeman chain code. The features are successfully trained by the ANN.

However, the system is not recognizing the entire hand sigh effectively all times. In some cases, the system misclassifies the hand sign. One of the reasons is that the orientation the hand sign. The another reason is that the almost similar shape such as জ and ত. Some hand sing shape is complicated to extract the original shape of the input hand sign such as ই.

TABLE I
RECOGNITION RATE OF TESTED SIGNS

S.No.	Testing Alphabet	Correctly Recognized (out of 10)	Recognition Rate
1.	অ	*10*	*100%*
2.	আ	*10*	*100%*
3.	ই	*9*	*90%*
4.	উ	*9*	*90%*
5.	খ	*10*	*100%*
6.	ঘ	*10*	*100%*
7.	ঙ	*10*	*100%*
8.	জ	*9*	*90%*
9.	ঠ	*10*	*100%*
10.	ড	*10*	*100%*
11	ন	*10*	*100%*
12	ত	*8*	*80%*
13	থ	*9*	*90%*
14	দ	*10*	*100%*
15	প	*10*	*100%*
16	ফ	*10*	*100%*
17	ব	*10*	*100%*
18	ম	*9*	*90%*
19	ল	*10*	*100%*
20.	ে	*10*	*100%*

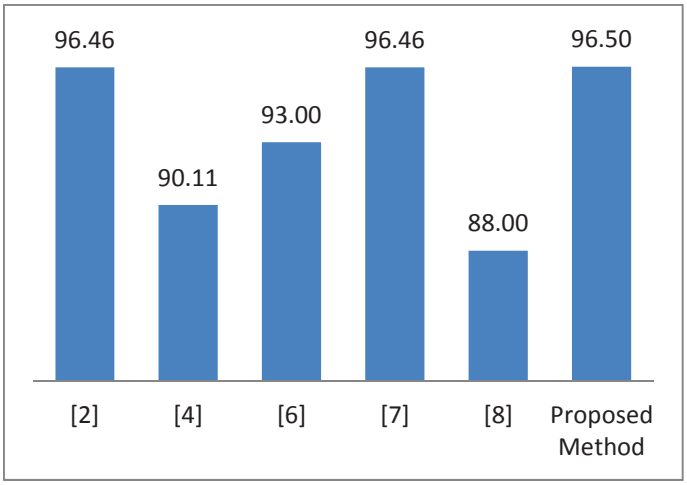


Fig. 9. Comparison of recognition rate of the proposed system with some existing related papers.

VI. CONCLUSION

In this paper proposed a system to recognize Bangla Sign Alphabets. And the goal is effectively met. This paper gives clear concept about Freeman chain code to extract feature vector. Artificial Neural Network is used as a classifier for the recognition purpose. Using Freeman Chain Code for feature extraction and ANN for identification is a different approach which is very rarely used in Bangla Sign Language recognition systems. For this proposed system, about 20 alphabets have been tested and most of them are recognized successfully. The proposed system is attained 96.5% recognition rate.

In future, this work will be extended for more hand sign letter and words. The recognition rate can be improved by making the training set bigger. The focus will be given to the background color and illumination factors in which have some limitations at the present time.

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