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Research paper

Extraction of Hand Gesture Features for Indian Sign languages using Combined DWT-DCT and Local Binary Pattern

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Abstract

The Hand Gesture system is based on two modes, viz, Enrollment mode and Recognition mode. In the enrollment mode, the Hand features are acquired from the camera and stored in a database along with the Sign languages. In the recognition mode, the hand features are re-acquired from the camera and compared against the stored Indian sign language data to determine the exact signs. In the pre-processing stage, two segmentation processes are proposed to extract the region of interest (ROI) of hand gesture. The first skin-color segmentation is used to extract the hand image from the background. The second region of interest of the hand gesture is segmented by using the valley detection algorithm. The Discrete Wavelet Transform (DWT) and Discrete Cosine Transform (DCT) are applied for the purpose of extracting the features. Further, the Sobel Operator and Local Binary Pattern (LBP) are used for increasing the number of features. The mean and standard deviation of DWT, DCT and LBP are computed.

Keywords: *Region of Interest (ROI), Skin-Color, Discrete Wavelet Transform (DWT), Discrete Cosine Transform (DCT), Sobel operator, Indian Sign Language (ISL) and Local Binary Pattern (LBP).*

1. Introduction

Sign language is the primary language of the people who are deaf or hard of hearing and also used by them who can hear but cannot physically speak. It is a complex but complete language which involves movement of hands, facial expressions and postures of the body. Sign language is not universal. Every country has its own native sign language. Each sign language has its own rule of grammar, word orders and pronunciation. The problem arises when deaf and dumb people try to communicate using this language with the people who are unaware of this language grammar. So it becomes necessary to develop an automatic and interactive interpreter to understand them.

Research for sign language recognition was started in the '90s. Hand gesture related research can be divided into two categories. One is based on electromagnetic gloves and sensors which determines hand shape, movements and orientation of the hand. But it is costly and not suitable for practical use. People want something more natural. Another one is based on computer vision based gesture recognition, which involves image processing techniques. Consequently, this category faces more complexity. Many researchers are working on hand gesture recognition using visual analysis. Indian Sign Language is one of the first known sign language systems and is considered extremely important in the history of sign languages, but it is rarely used today. In linguistic terms, sign languages are as rich and complex as any spoken language, despite the common misconception that they are not "real languages". Professional linguists have studied many sign languages and found that they exhibit the fundamental properties that exist in all languages [2]

The elements of a sign are Hand shape (or Hand form), Orientation (or Palm Orientation), Location (or Place of Articulation), Movement, and Facial Expression summarized in the acronym HOLME[4].

Sign languages, like spoken languages, organize elementary, meaningless phonemes into meaningful semantic units. Like in spoken languages, these meaningless units are represented as features, although often crude distinctions are also made in terms of manual and non-manual parameters. The manual parameters include hand shape, hand orientation, location and motion whereas the non-manual parameters include gaze, facial expression, mouth parameters, position and motion of the trunk and head [5]. Sign languages are independent of spoken languages and follow their own paths of development. The grammars of sign languages do not usually resemble that of spoken languages used in the same geographical area in fact, in terms of syntax, ASL shares more with spoken Japanese than it does with English. Actually, sign languages can convey meaning more than spoken languages by simultaneous means, e.g. by the use of space, two manual articulators, and the signer's face and body.

The Canny edge detection algorithm for the purpose of detecting points at which image brightness changes sharply. They used ANN algorithm for gesture identification for fast computational ability. Static hand gesture recognition analyzing three algorithms named Convexity defect, K curvature and Part based hand gesture recognition was developed using Microsoft Kinect sensors [4]. Microsoft's Kinect camera allows for capturing pseudo-3D image called the depth map which can easily segment the input image and track the image in 3D space. But this camera is very costly. In [5], three techniques were explored: K curvature, Convex Hull, Curvature of Perimeter for fingertip detection. A new approach was suggested called Curvature of Perimeter with its application as a virtual mouse. A static and dynamic hand gesture recognition system was proposed in depth data using dynamic time warping in [6]. A directional search algorithm allowed for entire hand

contour, the K curvature algorithm was employed to locate fingertips over that contour. Identification of Bengali Sign Language for 46 hand gestures was presented in [7]. Combined DWT-DCT was trained by feature vectors of the Linear Binary Pattern algorithm. A database of images of Indian signs was constructed. The experiment showed an accuracy of 87%. A real-time hand gesture recognition system algorithm is presented in this paper. This GUI is shown in Fig. 1.

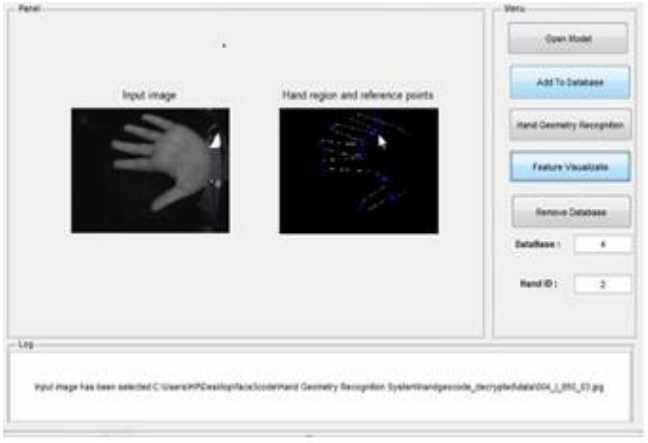

Fig. 1: Graphical User Interface

2. Methodology

The system is designed to visually recognize all static gestures of Indian Sign Language (ISL) with bare hand. Different users have different hand shapes and skin colors, making it more difficult for the system to recognize a gesture. The system combines five feature extraction algorithms for user independent and robust hand gesture recognition. The whole system works in four steps for gesture recognition such as image acquisition, preprocessing, feature extraction and feature recognition. The flow diagram of the proposed system is shown in Fig. 2.

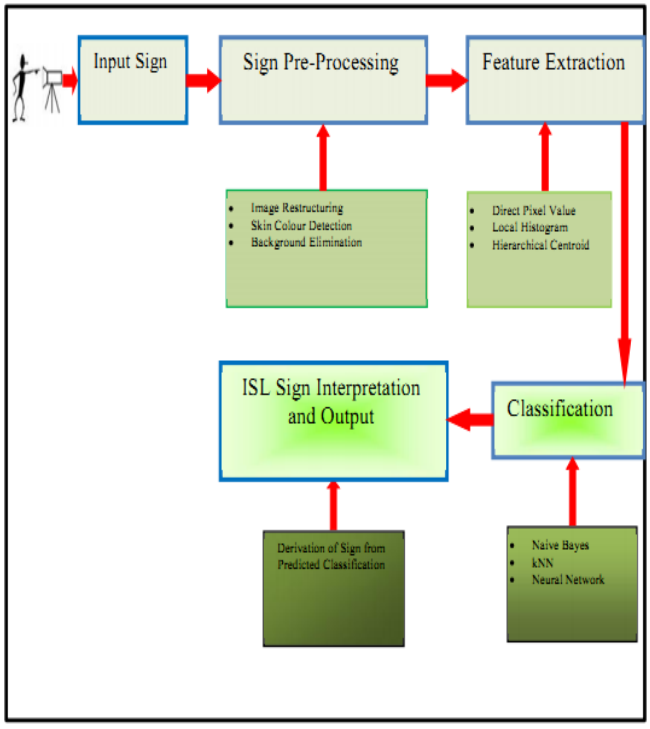

Fig. 2: Block diagram of sign language detection system

A. Image Acquisition

A total of 50 image samples of each sign of ISL is collected from different people. A database of 1850 images of 37 signs is created to extract feature vectors. The signs for all alphabets and numbers of ASL are shown in Fig. 3.

B. Preprocessing

Pre-processing of an image is necessary as the image received from the camera may contain different noises. At first, the images are resized to 260×260 pixels. Then, they are converted from RGB to binary by Global histogram threshold using Otsu's method. Then median filtering is done for removing noise and preserving the edges. Morphological bridge and diag are used for filling holes and smoothing the edges. For sign detection, the portion from wrist to fingers of a hand is needed. So the rest of the part is eliminated from the image by cropping it. Then the fingers of the images are needed to be aligned vertically upward. So the images are rotated from 0 to 360 degrees with respect to hand wrist position. At least 15 consecutive white pixels are searched at the bottom of an image to locate the wrist. If white pixels are found at the bottom of the image, then no rotation is needed. If not, then the image is rotated by 90 degrees clockwise and checked again. In this way, the loop continues until the wrist is found.

C. Feature Extraction

An image can be identified and classified by some points of interest or set of values called the features. In this paper, four distinct features such as Image Restructuring, Feature Selection, Edge detection, and rotation are used for feature extraction.

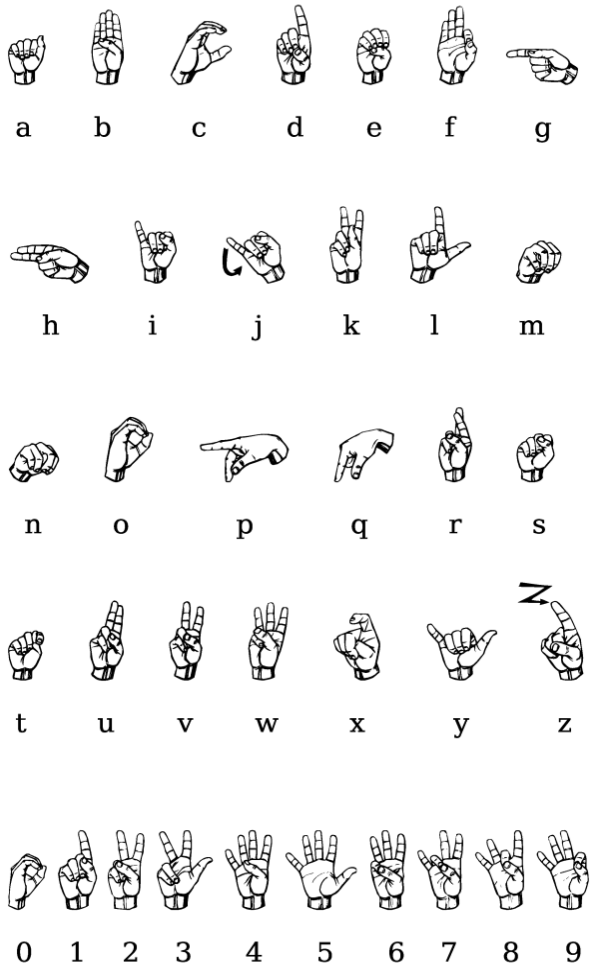

Fig. 3: ISL signs from the database

3. Proposed Algorithm for Feature Extraction

In this paper, four distinct features such as Image Restructuring, Feature Selection, Edge detection, and rotation are used for feature extraction. By increasing number of features and image samples, the system gets better accuracy and reliability.

A. Image Restructuring

In the first method, the input image, show in figure 4 static sign or frames extracted from input video is resized to 20×30 pixel followed by aconversion to a binary image as shown in figure 5. The converted binary imagecan be treated as a matrix of order 20×30. The elements of the matrix are either '1'or '0'. The zeros in the image matrix represent only background information. Theunwanted information from ISL sign images are removed by deleting all borderrows and columns having only '0' values.

Fig. 4: The ISL Static Sign Representing '2'

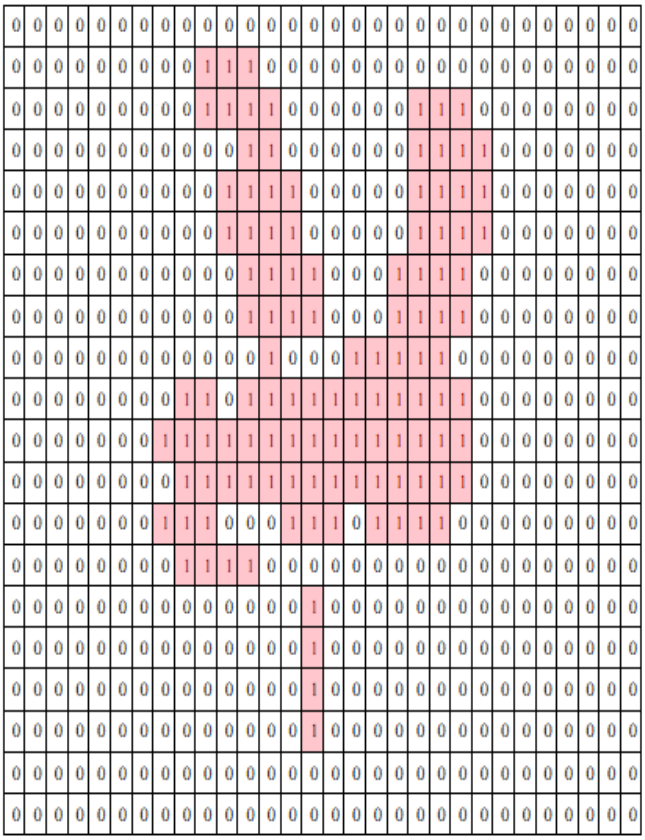

Fig. 5: Converted Binary Image of ISL Static Sign '2' (of figure 4)

B. Feature Selection

The feature extraction process involves two sub-processes namely feature construction and feature selection. Feature construction is the extraction of allfeatures available in the object. The size of feature vector in this stage can beequivalent to the actual size of object itself. In the second step, important featuresare selected from all constructed features of the object and are used in the patternrecognition. The feature selection procedures include the following:

- Data reduction for speed up the recognition process. The limited numberof input features implies faster execution of the recognition algorithm.
- To protect the buffer space allocated to the classification algorithm atvarious rounds.
- Easy to visualize the selected feature vector and handling errors in theclassification process.

The DWT and DCT are widely used in image processing. The DWT (Discrete Wavelet Transform) is mathematics tools which processed and represented the multi-resolution images. The DCT (Discrete Cosine Transform) is another transform which is converted the signals/pixels into afrequency domain. Those transforms can be used to extracted the edges from the image. Where, the palm has edge features (principal lines and wrinkles etc.), then the DWT and DCT were proposed to extract the features of Hand.

In this step, first the Discrete Wavelet Transform is applied to the Region of Interest of Hand. Four matrices were generated (approximation, horizontal, vertical and diagonal details). After that, the Discrete Cosine Transform is applied to the approximation matrix for the purpose of extracting the texture features of hand. Instead of using the four matrices elements as features, the mean and standard deviation are computed for each matrix.

The Discrete Cosine Transform is calculated with the following mathematics:

$$F(u) = \left(\frac{2}{N}\right)^{\frac{1}{2}} \sum_{i=0}^{N-1} \Lambda(i).cos\left[\frac{\pi.u}{2.N}(2i+1)\right] f(i)$$

The general equation for a 2D (*N* by *M* image) DCT is defined by the following equation:

$$F(u,v) = \left(\frac{2}{N}\right)^{\frac{1}{2}} \left(\frac{2}{M}\right)^{\frac{1}{2}} \sum_{i=0}^{N-1} \sum_{j=0}^{M-1} \Lambda(i).\Lambda(j).cos\left[\frac{\pi.u}{2.N}(2i+1)\right] cos\left[\frac{\pi.v}{2.M}(2j+1)\right] .f(i,j)$$

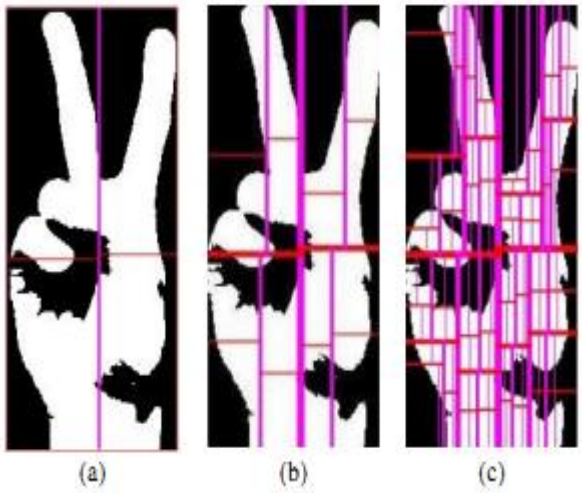

Fig. 6: Various Segmentation Levels of ISL Sign '2'
(a) Extracted Features using DWT & DCT Method at level 0,
(b) at level 1, (c) at level 2

C. Edge detection

The next step after hand shape detection is to find the exact shape of the hand from the detected skin pixels. For this purpose edge detection is used. Edge is the discontinuity in image intensity from

one image pixel to another pixel. An edge detected image can be used as an input for data compression, matching of image, feature extraction. Detection of edges filters out useless data and stores only the necessary information needed for future work under the condition that the important structural properties of the image are not loosed. For the sign language detection system optimal edge detection technique is canny edge detection technique. This algorithm satisfies various criteria of a good edge detector like including most edges by minimizing the error rate, marking edges closely as possible to the actual edges to maximize localization, and marking edges only once when a single edge exists for minimal response [9].

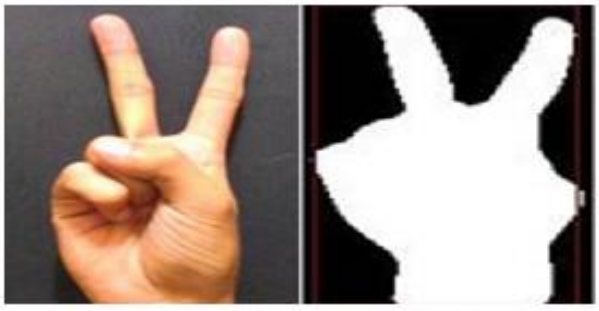

Fig. 7: Edge Detection using Sobel Edge Detector Operator

D. Rotation

In ISL, there are some signs which are very similar. The only difference between them is the rotation angle. In such cases, the rotation angle is the only feature that can differentiate those signs. In our research, some complex alphabet signs of ISL are replaced by other rotated ISL signs for better recognition rate.

4. Result Analysis &Discussion

A.Real Time Setup

An Android application called DroidCam is used for real time setup. It allows the mobile camera to take the input images of hand gestures with better resolution. A GUI is created that represents hand gestures by a letter or number on the computer screen as shown in Fig. 8.

Fig. 8: Real time environment of Sign Language Recognition

The input is a static sign representing 'FOUR' which is captured from a digital camera connected to a computer system. After processing, the system is able to interpret the sign as recognition system uses any one of three feature extraction methods but uses only Linear Binary Pattern classifier for predicting the signs.

B. Real Time Performance Analysis

To do a realtime hand gesture recognition performance analysis, each sign is taken from five different people. Two images are collected from each people while a black background and proper illumination are maintained. Features are extracted from the images and tested in the previously database-trained neural network. The number of correct responses out of 10 times of testing of each sign is shown in Table I.

Table 1: Real Time Hand Gesture Recognition Performance Analysis

Class	Number of Correct Responses (Out of 10)	Recognition Rate (%)
0	8	80
1	9	90
2	8	80
3	9	90
4	10	100
5	9	90
6	7	70
7	9	90
8	9	90
9	9	90
Average Recognition Rate = (87/100)×100 = 87 %		

The average recognition rate is calculated as follows:
*Average Recognition Rate = (No. of Correct Response) / (No. of Total Samples) * 100 %*
Real time average recognition rate of the proposed system was 87% (Table I).

5. Conclusion

In this paper we have presented an algorithm for hand gesture detection of Indian SignLanguage. Using Discreate Cosine Transform, Discrete Wavelet Transform and Edge detection algorithm the hand gestures are detected successfully for the ten numbers that has been experimented. Some images are not detected successfully due to geometric variations, uneven background and light conditions. After detection of the hand gestures the next step is to extract the features and classify them for recognition. Linear Binary Pattern matching algorithm will be used forfeature extraction and recognition respectively. The LBP is trained with 100 sample images of our database and it recognizes Indian Sign Language numbers with almost 87% accuracy in real time environment. Our future research will be extended for further improvement in recognition accuracy and also for movement detection of hand for alphabets recognition.

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