COMPUTER VISION BASED APPROACH FOR INDIAN SIGN LANGUAGE CHARACTER RECOGNITION

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Abstract— **Communication is the exchange of thoughts, messages, or information, as by speech, visuals, signals, writing, or behavior. Deaf and dumb people communicate among themselves using sign languages, but they find it difficult to expose themselves to the outside world. This paper proposes a computer based method for communication between deaf and dumb people with the outside world using computers. This method employs Indian sign language hand gestures given by the user as input through webcam and is converted into a text message. Unlike the conventional method for hand gesture recognition which makes use of gloves or markers or any other devices, this method does not require any additional hardware and makes the user comfortable. Efficiency is achieved by using a combination of different algorithms together to extract the features instead of relying on a single algorithm.**

Keywords: Indian Sign Language Recognition, Hand gesture recognition, hand segmentation

I. INTRODUCTION

Deaf and dumb people use their hands to express their ideas. The gestures include the formation of English alphabets. This is called sign language. When they communicate through the computer; the gestures may not be comfortable for the person on the other side. Therefore for them to understand easily, these gestures can be converted to messages. The sign language is regional. There is a separate sign language in America that uses only one hand for picturing the gestures. But the Indian sign language is totally different. It uses both the hands for representing the alphabets. While there are a lot of efforts going into American Sign Language detection the same cannot be said about Indian Sign Language. The existing systems for gesture recognition can decide their own hand gestures for any action, but this paper proposes recognition of Standard Indian sign language gestures. The main difference to other similar systems is that the proposed system does not require any additional hardware. This paper suggests a technique to input hand gestures through webcam connected to the computer. Image processing techniques are being used to identify the gestures.

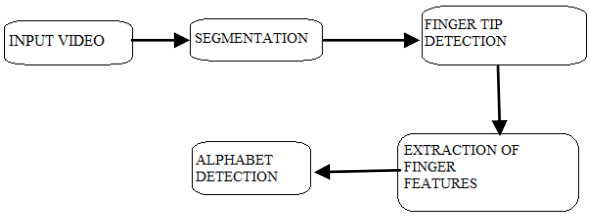

Fig 1: Block diagram for proposed method

The input image is segmented for processing. After segmentation, the regions like finger, palm is extracted. From the extracted region of the fingers, finger tip is detected. The distance between the fingers is calculated. The different features of the fingers like angle, posture of the finger are detected. The posture of the finger specifies whether the finger is semi closed, half closed, fully closed or fully open. These features are stored as vector training and for each sign alphabet. These vectors are then used for recognizing the correct gesture. Some of these points are discussed in this paper which is organized in the following sections. Section 2 talks about the various techniques available, their advantages and disadvantages. Section 3 deals with various methods used for extracting the different features of the hand. Section 4 contains the different results obtained on experimenting different inputs. Conclusion and future work is given in the section 5.

II. LITERATURE SURVEY

This is about a general survey on the various techniques used for recognition of hand using various gesture techniques available. There are various techniques used for recognition of gestures which can be applied in two different stages. The methods are Feature Extraction, Learning Algorithm. Various techniques are used in each method. From the image of the hand various features are extracted in the form of mathematical quantities from the data available, in feature extraction. The hand region alone has to be obtained for processing, for which there are several techniques available that includes extraction using threshold values, combining collection of low level information to high level feature information, projecting the object using Eigen vectors, detecting finger tips by segmentation, using the concept of kinematics and dynamics of the body [2]. Using learning algorithms the image extracted is studied in depth to get more information. Learning algorithms include Neural Networks, Hidden Markov Model, and Support Vector Machine (SVM).

SVM [5] is a supervised algorithm used to analyze data and patterns used for classification purpose. This algorithm talks about maximizing the margin between the planes i.e. the distance between the decision point and the closest point will be increased. The basic SVM takes a set of input data and predicts, for each given input, which of two possible classes forms the input, making it a non-probabilistic binary linear classifier. The drawback of this model is it's time complexity.

A Hidden Markov model [3] is a collection of finite states connected by transitions. Each state is characterized by two sets of probabilities: a transition probability, and either a discrete output probability distribution or continuous output probability density function which, given the state, defines the condition probability of emitting each output symbol from a finite alphabet or a continuous random vector.

The term neural network was traditionally used to refer to a network or circuit of biological neurons. Neural networks [4] are used for solving artificial intelligence problems without necessarily creating a model of a real biological system. Neural network algorithms attempt to abstract this complexity and focus on what may hypothetically matter most from an information processing point of view. Another incentive for these abstractions is to reduce the amount of computation required to simulate artificial neural networks, so as to allow one to experiment with larger networks and train them on larger data sets.

III. PROPOSED METHODOLOGY

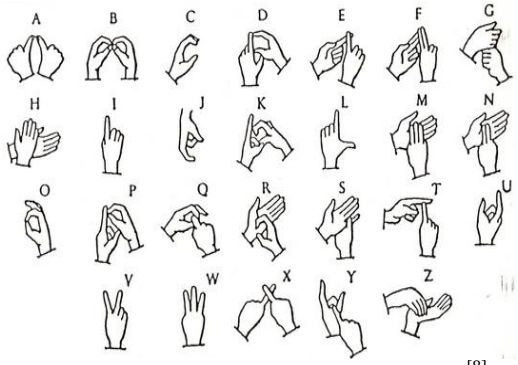

Fig 2: Indian Sign language – Characters[8]

The alphabets in Indian Sign Language shown in Figure 2, uses both the hands which differentiate it from American Sign Language. Indian Sign Language characters are almost similar to the characters themselves. Hence the start of the project will be with the input of gestures through a webcam and the output will be the alphabet in the text format. The overall flow of process is given through the following block diagram (Fig 3) which explains clearly about the phases in the whole process. Starting from the webcam, the input will be sent to the system. The input image is segmented using the HSI colour based model. This segmented image is then processed under distance transform method by which the binary image is found. The binary image is used for the process of dilation and erosion which gives the region extraction part. From these processes, the extracted region will be the finger region and the palm region in separate versions. Then using the binary image, the finger tips are detected and the length of each finger is calculated. From that the finger is detected and their features like closeness of the finger, angle between the fingers are calculated. From these features, the alphabets are recognized since each alphabet has its own features different from others. By this the output can be achieved.

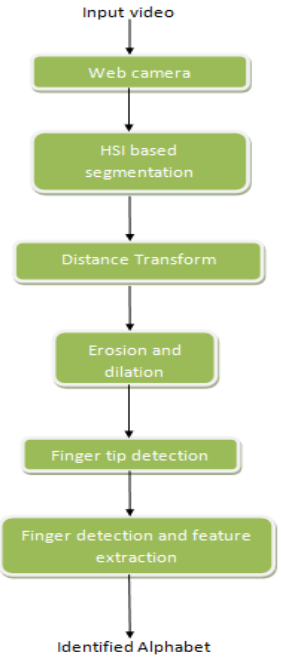

Fig 3: Overall Flow of The System

A. Segmentation

This method does not use glove, so the skin colour has to be recognised for identifying the hand gestures. So the input that is taken through the webcam is first divided into frames for processing. The input images are in RGB colour model. In the RGB colour model change in luminosity affects the image quality. So this image is first converted to HSI model [6] (Hue Saturation Intensity). This transformation separates the luminosity component (i.e. intensity) from the colour components. One assumption made is that the hand is the largest object in the input image. The hand region is identified to have a Hue and Saturation values as follows

H<25 or H>230 and S<25 or S>230

After pre-processing a combination of several algorithms are used for extracting required features and hence identifying different sign language gestures. A subset of algorithms has been implemented so far.

B. Fingertip detection

The number of active fingers has to known to identify the gesture. So the fingertip is calculated. To calculate this, the tangential angle between the two fingers is obtained. A graph is plotter with the boundary number in the x-axis and angle in the y-axis. This graph is used to count the number if transitions from white to black region. The region where the curve falls down is identified using differential filter as the fingertip. This number gives the number of active fingers. After obtaining the number of active fingers the gesture can be determined using fingertips.

C. Distance Transform Method

Distance transform method [6] is used to identify the extent of the closure. In this method, the Euclidian distance between each white pixel and the centroid is calculated. The pixels closest to the centroid are given a high intensity and as the distance increases the intensity decreased. Using an appropriate structuring element (a disc) of appropriate size the hand and palm regions are identified and separated using erosion dilation and subtraction process.

Line segments are drawn substituting the fingers and the angle between the fingers is found out. This angle gives vital information to distinguish sign language gestures having the same number of open fingers. Further fully close, fully open and half open states of each finger are obtained using the lengths of the fingers.

D. Finger Division

From the distance transform method we got the fully opened hand with the farthest distance from the palm. But the fingers have to bend for some characters. In such a case, the opened fingers alone cannot be used. So in order to include those cases, the hand is divided into three parts. As the distance between the tip of the finger and the intersection of palm and finger region of each finger is known, then the two points can be found as

x = 1/3*major axis1ength

y = 2/3*major axis length

After calculating, the points are plotted. But if the finger is not open the finger is not at all detected.

E. Finger detection

During the initial training phase which lasts for 50 frames, the length of each finger and the distance of each open finger to every other finger are found and an upper triangular matrix is obtained. Again during the experimental phase, length of each finger and the distance between them is calculated and compared with the values obtained during training phase. From this the fingers are identified and can tell whether the finger is semi closed or half closed, etc. Based on these features the recognition is done during the actual sign language recognition phase.

The 26 alphabets in the Indian Sign Language and the features required for their recognition is shown in Table 1 and Table 2. As we can see many symbols have used both hands, some with fully opened fingers, some with semi closed and some with half closed. So first an attempt was made for identifying the differences between them to organize and combine them into several groups in order to classify them. Since classification will help in the stage of recognizing the characters as a group. The difference between the alphabets occurs in the angle between them, which finger is open, how much the particular finger is open and how many fingers are open.

Table 1 – Features of Alphabets Using Two Hands

Alphabet	Finger opened	Number of fingers	Angle Between	Posture
A	Thumb	Two	90(between two thumbs)	Fully opened
B	All	Ten	30(between all fingers of both hands)	All - Half closed

Table 1 – Features of Alphabets Using Two Hands

Alphabet	Finger opened	Number of fingers	Angle Between	Posture
D	Thumb and two Index fingers	Three	150(between thumb and a index)	Index – Semi closed
E	Index	Two	0	Fully opened
F	Index and Middle of both hands	Four	0	Fully opened
G	All	Ten	0	All – Half closed
H	All	Ten	0	All – Fully opened
K	Index of both hands	Two	45(between both index)	One Index – Semi closed
M	All fingers in one hand and middle three fingers in other	Eight	0	Fully opened
N	All fingers in one hand and middle, index in other	Seven	0	Fully opened
P	Thumb and Index of both hands	Three	135(between thumb and a index)	One Index and Thumb – Half closed
Q	Thumb and Index of both hands	Three	0	All – Half closed

Table 1- Fetaures of Alphabets Using Two Hands

R	All fingers in one hand and thumb, index in other	Seven	0	Thumb and index of other hand – Half closed
S	All fingers in one hand and thumb in other	Six	0	Thumb in other hand – Fully closed
T	Index of both	Two	90	Fully opened
X	Index of both	Two	90	Fully opened
Y	Thumb and Index of both	Three	150(between thumb and a index)	Index – Semi closed
Z	All	Ten	150	Fully opened

Table 2: Features of Alphabets Using One Hand

Alphabet	Finger opened	Number of fingers	Angle between	Posture
C	Thumb and Index	Two	150	Index - Semi closed
I	Index	One	0	Fully opened
J	Thumb and Index	Two	150	Index – Semi closed
L	Thumb and Index	Two	90	Fully opened
O	Thumb and Index	Two	0	Both – Half closed

Table 2: Features of Alphabets Using One Hand

U	Thumb and Index	Two	150	Index – Semi closed
V	Index and Middle	Two	45	Fully opened
W	Index, Middle and Ring	Three	20(between index and middle, between middle and ring)	Fully opened

Note that these angles are just an approximate threshold because at runtime the hand position of the person showing the gestures changes and hence the angle changes.

IV. EXPERIMENTAL RESULTS

The experiment results of the experiment phase which comes after the training phase for the 50 frames is given below. Fig 4 is the input image given through the webcam .It represents one of the 50 frames of the input video.

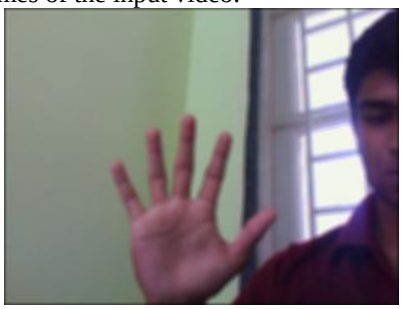

Fig 4: Input Image

This distance transform is performed on this input image and a binary image is obtained. In this phase, the binary image of the input image is achieved. From the binary image, using erosion and dilation process we get the palm region separately. Now we subtract the original binary image from the palm image to obtain the fingers. Fig 5 is the binary image of the input image in fig 4. Fig 6 is the fingers of the input image. Fig 7 is the remaining region apart from the fingers.

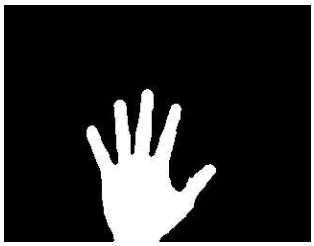

Fig 5: Binary Image

Fig 6: Finger region

Fig 7: Palm region

After completing the erosion and dilation process, using the distance transform method, the longest distance is calculated and the output of the distance transform is given by fig 8.

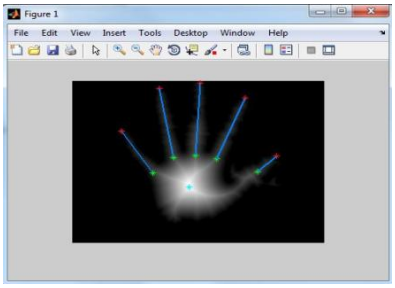

Fig 8: A full open hand using distance transform method

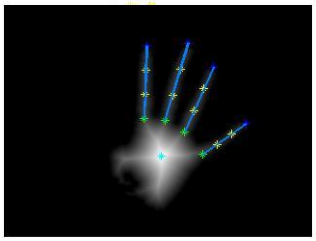

Fig 9: Four Fingers with the partitions of three in each

From this output, each finger's length is divided into 3 parts as shown in fig 9.
By following the procedure explained above, the following results are obtained and their accuracies are plotted.

Table 3: Accuracy Depending On Posture

Hand gestures	Number of frames identified correctly	Number of frames for which gestures were shown correctly	Accuracy in percentage
One finger half closed	27	45	60
Two fingers fully closed	17	41	41
Two continuous fingers full closed	20	22	91

Three fingers fully closed	34	45	76
All fingers open	43	50	86
Index finger closed	40	45	89
Thumb closed	44	44	100

We repeated the experiment by closing each finger and examined the difference in them. The table above is the result obtained and their respective accuracies. The experiment is not only repeated for features of the finger but it is also repeated for different brightness conditions.

Table 4: Accuracy after Brightness Enhancement

Hand gestures	Number of frames identified correctly	Number of frames for which gestures were shown correctly	Accuracy in percentage
Ring closed	33	39	85
Three fingers fully closed	46	46	100
All fingers open	50	50	100
Index finger closed	42	43	98
Thumb closed	35	35	100

The brightness of the input image was increased by 10 percent and detection was attempted. The results obtained were better than previous trails. Table 4 shows accuracy levels after brightness enhancement.

V. CONCLUSION AND FUTURE WORK

The implementation of distance transform for both the hands is going on, since most of the gestures in Indian Sign Language involve two hands. Also there is scope for expanding it to body gestures as well. So far only the features of the English characters have been obtained. We are still working on recognition techniques for recognizing the alphabet from the obtained features of the hand and we are still looking for other algorithms to help identify other potential features to further expand the detection capability of the system.

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