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Hand Gesture Recognition via Covariance Method

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Abstract-Gesture is a powerful form of communication among humans. This paper presents simple as well as effective method of realizing hand gesture recognition using Covariance Method. First an image database is created which constitutes various static hand gesture images. These images are a subset of American Sign Language (ASL). Preprocessing of the image is done so as to reduce the amount of noise present in the image. Eigen values of the Eigen vectors are calculated. A pattern recognition system is used to transform an image into feature vector i.e. Eigen image, which will then be compared with the trained set of gestures. The method used was successful to retrieve the correct match.

Keywords: Covariance, Pattern Recognition.

I. INTRODUCTION

Gestures are powerful tools of communication among humans and are of particular interest to the deaf and dumb community. They are so deep rooted that people continue gesturing even while speaking on phone. Hand gestures and finger orientation have a scope for human machine interaction. The system's memory stores all the images, distance transform and all information required for comparison. There are three methods for hand gesture analysis firstly use of data gloves or marked glove which employs sensors that are connected to gloves converting flexions to electrical signal; secondly vision based technique based on how we perceive information about our surroundings and finally analysis by drawing gestures with use of a stylus as an input device. Our work will be based on vision based hand gesture recognition which is by-far the most natural method .The objective of this paper is to compare techniques of Vision based hand gesture recognition system and to consolidate various previously available approaches.

This system involves two phases: training and running phase. In the training phase, the user shows the system one or more examples of hand gestures. The system stores the Eigen image of the hand shape and in the run phase the computer compares the current hand shape with each of stored shapes by coefficients. The best match gesture is selected by the covariance method.

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II. IMAGE DATABASE

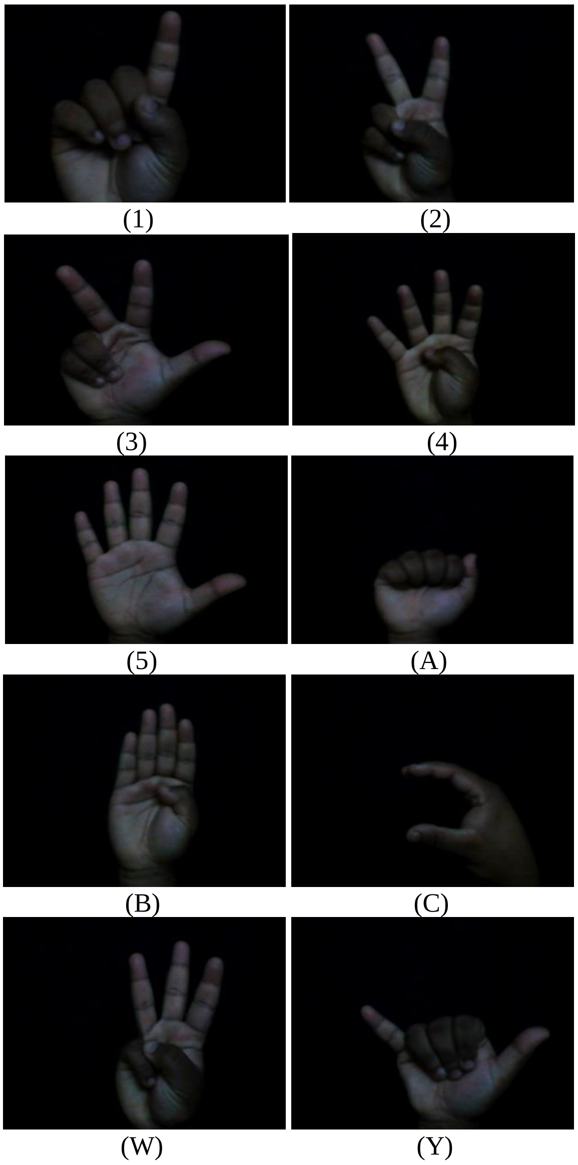

Fig. 1 Ten ASL gestures used with their names

First of all an image database is created., These images are taken from American sign language (ASL).ASL consists of about 6000 gestures of common words out of which 10 gestures are used. .These images were captured using an USB webcam. Gestures D and E were not used because of their possible confusion with gestures for number '1' and 'A' respectively rather simple gestures 'W' and 'Y' are used. The 10 gestures used along with their names are shown above

III. PRE-PROCESSING

Preprocessing is done so to make the image easier to analyze.

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It is applied to images before we can extract features from hand images. In the preprocessing stage the RGB image is converted into grayscale image and the resizing of the entire set of image is done

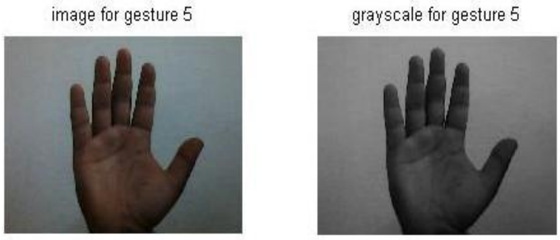

Fig. 2 Gesture and its grayscale equivalent

Variance is another measure of the spread out of data in a set. In fact it is the square of the standard deviation, whereas Covariance is a statistical measure of the extent to which two random features vary together. Covariance can be a negative, positive or zero number, depending on what is the relation between two features. If the features increase together, the covariance is positive, one feature increases and other decreases, the covariance is negative, and if the two features are independent, the covariance is zero. The covariance matrix provides a natural way of fusing multiple features which might be correlated the covariance is a 2-dimensional measurement. The covariance is a really important knowledge for the PCA method. The covariance will allow us to see if there is any relationship between the different dimensions of the data set. The definition for the covariance matrix for a set of data with n dimensions is:

$C_{nxn} = (C_{I,J} , C_{I,J} = cov (D_I,D_J))$ ....(1)

Where $C_{n\,x\,n}$ is a matrix with n rows and n columns, and Dx is the xth dimension. If you have an n dimensional data set, then the matrix has n rows and columns (so is square) and each entry in the matrix is the result of calculating the covariance between two separate dimensions. For example the entry on row 2, column 3, is the covariance value calculate between the 2nd dimension and the 3rd dimension.

IV. EIGEN VECTORS AND EIGEN VALUE

Eigenvectors of a linear operator are non-zero vectors which, when operated upon by the operator, result in a scalar multiple of them. Eigen value is a value which is associated with each Eigen vector. The Eigen value gives us some information about the importance of the eigenvector. The Eigen values are really important in the PCA method, because they will permit to realize some threshold to filter the non-significant eigenvectors, so that we can keep just the principal ones. Eigen Vectors can only be found for square matrices. Not every square matrix has Eigen vectors. An N x N matrix that has Eigen vector's will have N of them. If we scale the vector by some amount before multiplying it, we will still get the still get the same multiple of it as a result. . All the Eigen vectors are perpendicular i.e. at right angle regardless of their dimensions. The concept of is to reduce the size of the images to be recognized from a high to a lower dimension. While lowering the dimensionality in the set, using the eigenvector method also highlights the variance within the set. By performing singular value decomposition on an average covariance matrix we can find the Eigen values and eigenvectors

$Cu = \lambda k$............................... (2)

Where C is the average covariance image matrix, k corresponds to the eigenvectors and λ corresponds to the Eigen values of C

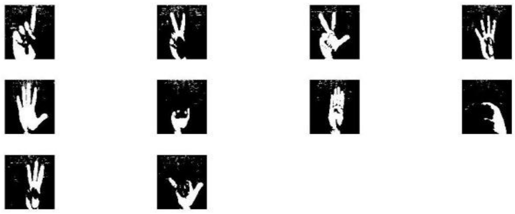

Fig. 3 Eigen Image of the ten chosen ASL gestures

V. GESTURE RECOGNITION

The main idea of PCA is based on the eigenvectors of the covariance matrix of the group of hand posture training images. These eigenvectors can be thought of as a group of features which characterize the variation between hand posture training images. Hand posture training images are projected into the subspace spanned by a hand posture space. The hand posture space is defined by the eigenspace which are the eigenvectors of the set of hand postures. Each training image corresponds to each Eigenvector. An eigenvector can be shown as an eigenspace.

Then in the testing stage, every detected hand posture is classified by comparing its position in hand posture space with the positions of every hand posture training images. Each hand posture image in the training set is represented a linear combination of the eigenspace, which indicate a feature space that spans the variations among the known hand posture training images. The number of eigenspace is equal to the number of hand posture images in the training set. The hand postures can also be approximated using only the best eigenspace, which have the largest Eigen values.

First we read all the data set pictures, to treat the contrast (to normalize the pictures), to apply a Gaussian filter and to resize them in a vector. Then we resize all images the database to 200 x 180. This is achieved in MATLAB using imresize command. Then we reshape the images to get elements along rows as we take Input Image. The next step is to calculate the mean of each direction. It is a fast step. We just had to take the first matrix of all the images, and then to ask to MATLAB to calculate the mean of the matrix.

Then, we subtracted it to the first matrix. Cov(x) or Cov(x,y) normalizes by N – 1, if N > 1, where N is the number of observations. This makes Cov(X) the best unbiased estimate of the covariance matrix if the observations are from a normal distribution. For N = 1, Cov normalizes by N. it is really important to choose the good eigenvectors to express the data set with the best base. The number of eigenvectors chooses will be in direct relations with the results that we get. To recognize an unknown hand posture image in the testing stage, its weight (wi) is calculated by multiplying the eigenvector (ui) of the covariance matrix (C_v) with difference image $(\Gamma - \Psi) = \Phi$ $w_i = u_i^T(\Gamma - \Psi)$. Now the weight vector of the unknown image becomes

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$\Omega = [w_1\ w_2\ w_3\ \ldots\ldots\ldots\ldots w_m]^T$................ (3)

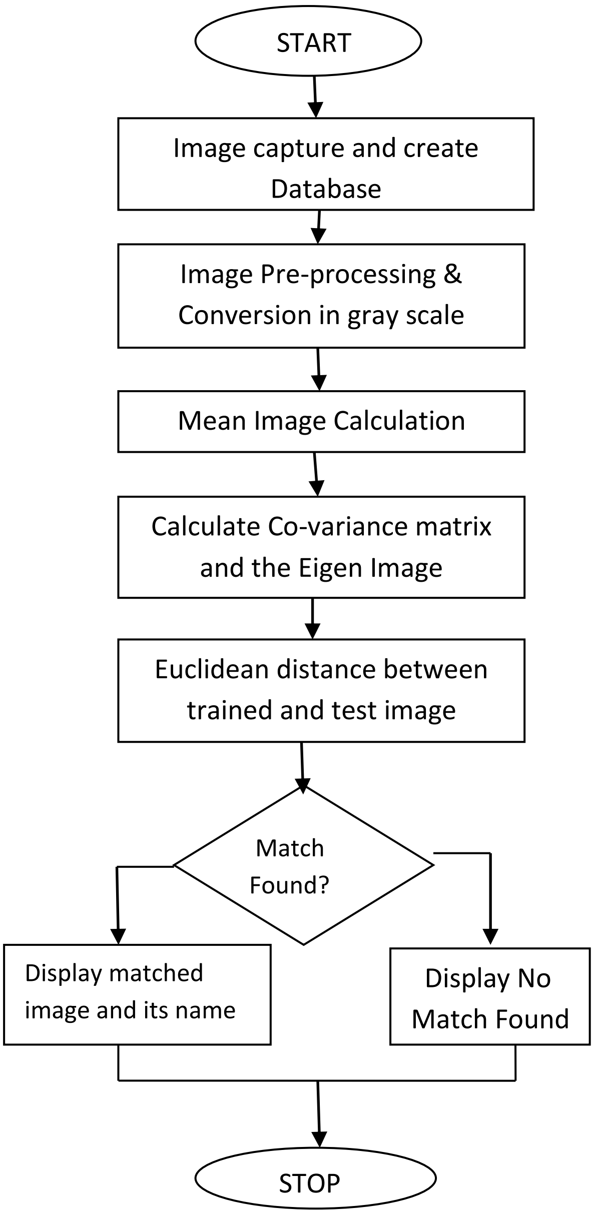

Fig. 4 Flowchart of the HGR system

The minimum Euclidean distance between test image and each training image is defined by ϵ_v = minimum $||\ \Omega - \Omega_k\ ||$....................... (4) k = 1, 2........ M Where M is the number of images trained. Then, Γ is recognized as hand posture *k* from the training images set.

VI. RESULT

The system is run on a Lenovo B480 Core i3 processor notebook computer with 4GB RAM, running on Windows 8. The camera used is a Logitech Quick cam Chat. The images were captured at a resolution of 640x480 pixels. The camera was placed at a stationary position in front of the signer. The signer was required to only place their hand within the view of the camera and no other body part. As far as possible the wrist of the signer was not included in the training data.200 images were tested in all, twenty for each of the 10 gestures.

GESTURES MEANING	NO.OF IMAGES	GESTURES CORRECTLY IDENTIFIED	RECOGNITION (%)
1	20	18	90
2	20	17	85
3	20	19	95
4	20	18	90
5	20	19	95
A	20	17	85
B	20	18	90
C	20	17	85
W	20	18	90
Y	20	19	95

Table 1: Individual Gesture's Recognition Rate

Total Number of Test Images = 200

Total Gesture Images Correctly Identified = 180

Recognition Rate

$$= \frac{\text{Total Gesture Images Correctly Identified}}{\text{Total Number of Test Images}} \text{ X } 100$$

$$= \frac{180}{200} \text{ x } 100 = 90\ \%$$

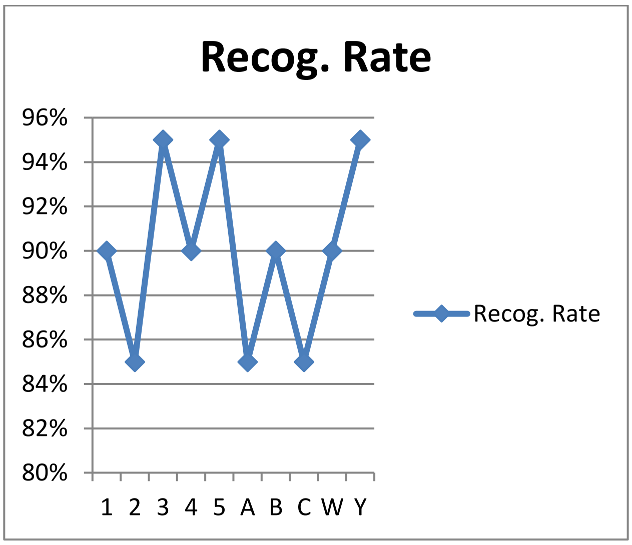

Fig. 5 Gesture vs. Recognition rate

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VII. DISSCUSSION

Our work was done using static gestures, but with advances in recent technology hand gesture will have to be realized in real time i.e. dynamic gestures.

While the prior work done before ours only focused on any one method this system uses three different methods for gesture recognition with which the best method can be found.

Some of the applications of this project can be in the field of robotics where the robots can be socially assistive by interpreting the meaning of the hand gesture recognized. Strong gesture recognition can be used an alternative computer interface, which can allow users to accomplish common tasks like opening up files etc. Another use of gesture recognition is in the field of security where authorization can be provided only on recognizing only any particular or combination of hand gestures.

VIII. FUTURE WORK

Further enhancement of the techniques proposed is possible with better segmentation of the image. Experiments will have to be done on a larger scale so that results can be more accurate. Edge detection technology keeps on changing so constant improvement is possible, also line detection can also be used to solve some problems.

Some of the applications of this project can be in the field of robotics where the robots can be socially assistive by interpreting the meaning of the recognized hand gesture. Strong gesture recognition can be used an alternative computer interface, which can allow users to accomplish common tasks like opening up files etc. Another use of gesture recognition can be in the field of security where authorization may be provided only on recognizing a particular or combination of hand gestures.

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