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Efficient Principal Component Analysis for Recognition of Human Facial Expressions

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Abstract: Facial Expression Detection deals with an Expression of an image and recognizes which expression it is such as Happy, Sad, and Neutral etc. The proposed method uses picture database for analysis of principal components. We have presented an Eigenvector based system to recognize facial expressions from digital facial images. In the approach, projected versions of all the reference database images and test database images are created. The Euclidian distance of a projected test database image from all the projected reference database images are computed and the lowest (minimum) value is selected in order to determine the reference database image which is most similar to the test database image.

Keywords: Eigenvectors, Eigen values, PCA, Face recognition, Image processing, Facial expression, Euclidian distance.

I. INTRODUCTION

Now a day the most demanding task or situation is Computer vision. Need for extraction of information from images is very large. According to Ekman and Friesen, people are born with the ability to generate and interpret only six facial expressions: happiness, anger, disgust, fear, surprise and sadness [5]. Humans learn rest of the facial expressions from the surrounding areas. Human beings can recognize facial expressions easily but it is difficult for computer to do this job. Therefore it is necessary to develop automatic facial recognition system. A human face carries a lot of important information while interacting to one another. In social interaction, the most common communicative hint is given by one's facial expression. Facial expressions can be represented through: Pictures, Video, Cartoons, Smiley, Facial characteristic points, Active Action Units [1]. FER by computer plays an important role in many applications Such as human behavior interpretation and human-computer interface. The proposed method was carried out by taking the picture database. The database was obtained with three photographs of persons at different expressions. These expressions can be classified into some discrete classes like happy, sad and neutral. If there is no expression then it is classified as "neutral" expression. There are three persons in database. The database is kept in the reference folder which contains each person having all his/her photographs. Another database was also prepared for testing phase by taking photographs of persons in different expressions and conditions such as lighting, background, distance from camera etc. And these database images were stored in reference folder. In the reference and testing phase, the Eigenvector of the images are computed. Using PCA the Euclidian distance of a projected test image from all the projected reference images are obtained and the minimum value is chosen in order to determine the reference image which is most similar or near to the test image. The intensity of particular expression is determined by the differences in the Euclidian distance obtained from the mean of the projected neutral images.

II. Proposed Human Faceal Recognition System

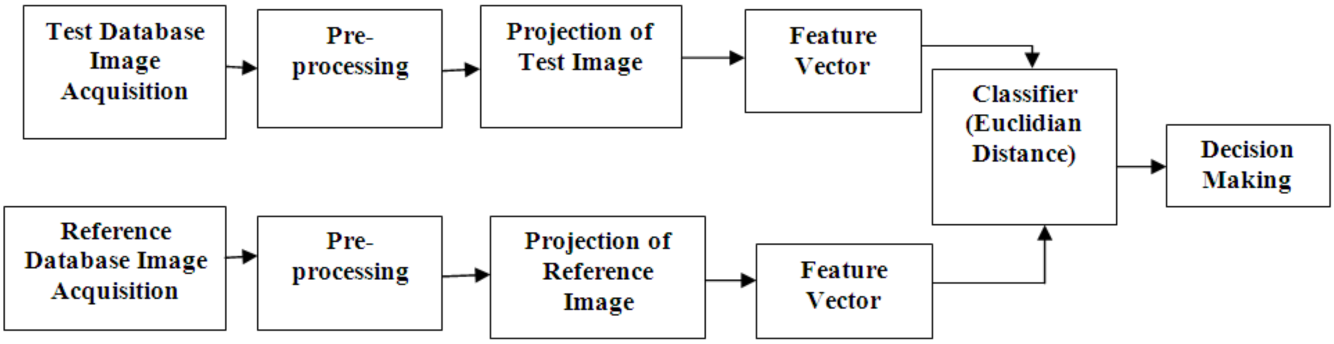


Image acquisition: Digital camera is used for acquiring images. Facial expression recognition is done by using stable images. First all the images are stored in reference database and test database and then converted into gray-scale images before going for further processing. Reference database consist of nine images of three expressions. Each expression consists of three images of each person with different expression. Test database consist of input images. In this implementation, all images are resized from 375x300 to a uniform dimension of 280x180. Figure no:2 shows reference database images considered for facial Expression recognition. The following database has numbering from Image 001 to Image 009 respectively used for reference purpose and these characteristics are given in results table.

Figure No:2 For Reference Samples

The following database has numbering from Image 001 to Image 003 respectively used for testing purpose and these characteristics are given in results table.

Figure no:3 For Test Samples

***Pre-Processing**:* After entering the data into facial expression recognition system next step is pre-processing. Very important task in facial expression recognition system which involves stages such as image resize, Lighting Compensation, Edge detection, Extract Skin, noise removal, and normalization against the variation of pixel position or brightness and locating face position. Pre-processing is applied to images in reference database and test database. In preprocessing module images are resized from 375x300 pixel value to 280 x 180 pixel values. Image Segmentation deals with fixing of boundaries of image portions providing appropriate facial information. Edge detection is done by functions such as Sobel method, Prewitt method and Roberts's method. By default edge detection uses sobel method to detect the edges of images.

Principal Component Analysis: Principal Component Analysis (PCA) is a technique which identifies patterns in data and expresses the data such that its similarities and differences are highlighted. PCA is a useful tool where it is difficult to find patterns in data of high dimension data. The other important thing of PCA is that once the patterns in data are found, the data can be compressed i.e the number of dimensions are reduced but there is not much loss of information. Image compression uses this technique.Principal Component Analysis (PCA) is uses mathematical principles to converts large dimensional variables into smaller dimensional variables called principal components. PCA is an information theory approach of coding and decoding face images may give insight into the information content of face images, emphasizing the significant local and global "features". Such features may or may not be directly related to face features such as eyes, nose, lips, and hair. In the language of information theory, we want to extract the relevant information in a face image, encode it as efficiently as possible, and compare one face encoding with a database of models encoded similarly. A simple approach to extracting the information contained in an image of face is to somehow capture the variation in a collection of images, independent of any judgment of features, and use this information to encode and compare individual face images.

PCA uses a vector space transform to reduce the dimensionality of large data sets. Using mathematical projection, the original data set, which may have involved many variables, can often be interpreted in just a few variables (principal components). These eigenvectors can be thought of as a set of features that together characterize the variation between face images. Each image location contributes more or less of each eigen vector, so that we can display the eigenvector as a sort of ghostly face which we call an ***eigenface***.

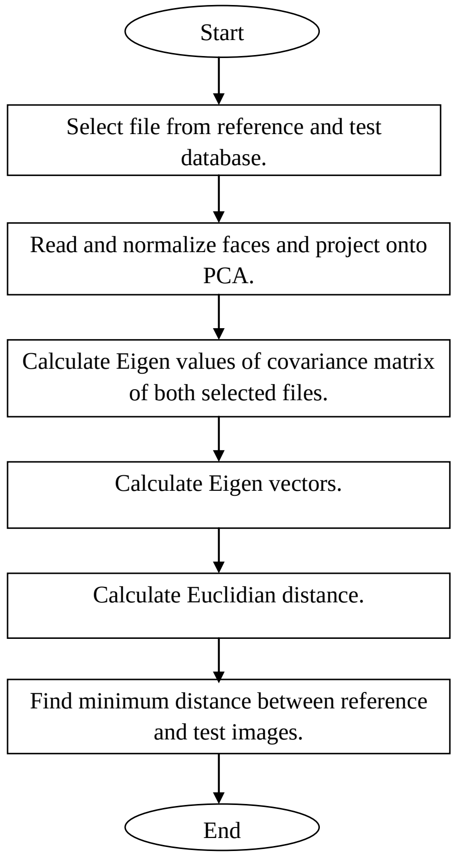
III. Steps Involved in PCA

Take an input image. Subtract the mean. Obtain the co-variance matrix. Compute Eigen values and Eigen vectors of the obtained co-variance matrix. Select the principal components. Format the feature vector. Obtain new data.

Feature vector: Feature vector deals with extraction of features or part of face. When input from previous stage comes to feature vector it reduces the input data or information into set of features which are to be represented. This is called feature extraction. It simplifies the way or quantity of help or information needed to describe or represent large set amount of data accurately. There are two types of features that are usually used to describe facial expression: geometric features and appearance features [2]. Feature vectors convert's pixel data into a higher-level representation of shape, motion, color, texture, and spatial configuration of the face or its components [1]. The classification of expressions is done depending on these vectors.

Classification: The expressions are divided into different categories by a classifier. The input to the classifier is a set of features which are obtained from face region in the previous stage. The set of features are formed and these help to describe the facial expression. In this, the classifier based on the Euclidean distance has been used which is obtained by calculating the distance between the image which are to be tested and the already available images used as the reference images. Then the minimum distance is observed from the set of values. In testing, the Euclidean distance (ED) has been computed between the new (testing) image Eigenvector and the Eigen subspaces for each expression, and minimum Euclidean distance based classification is done to recognize the expression of the input image. There are a lot of different machine learning techniques for classification task, namely: K-Nearest Neighbors, Artificial Neural Networks, Support Vector Machines, Hidden Markov Models, Expert Systems with rule based classifier, Bayesian Networks or Boosting Techniques (Adaboost, Gentle boost) [2].

IV. FLOWCHART



Algorithm:

1) Image is taken as input from test database and reference database.
2) The images undergo preprocessing such as image resizes, Lighting Compensation, Extract Skin, noise removal.
3) The reference images are utilized to create a low dimensional face space. This is done by performing Principal Component Analysis (PCA) in the reference image set and taking the principal components (i.e. Eigen vectors with greater Eigen values). In this process, projected versions of all the reference images are also created.
4) The test images also projected on face space.
5) The Euclidian distance of a projected test image from all the projected reference images are computed and the minimum value is chosen in order to determine the reference image which is most similar or matches to the test image.
6) The intensity of a particular expression is determined by the Euclidian distance from the mean of the projected neutral images.
7) Based on this Euclidian distance, the expression is classified into neutral, happy or sad category.

V. EXPERIMENTAL RESULT

Table no.3: Experimental Result for Neutral Expression

Testing image	**Euclidean distance between test expressions and mean of neutral expressions**	**Reference database images**	**Euclidean distance between test expressions and all reference expressions.**
			11989.4493380501
			5690.26310978571
			5203.93752410603
			9257.81493812222
	4176.54422134513		6808.36375334300
			6345.6787033499
			10642.932100621
			11779.891497139
			11000.033079333
Recognized Expression			
Test Image	**Distance From Neutral**	**Expression**	**Best Match Of Reference database Image**
Image 002	**3177**	**Neutral**	**Image 003**

Testing image	**Euclidean distance between test expressions and mean of neutral expressions**	**Reference database images**	**Euclidean distance between test expressions and all reference expressions.**
			13896.4940024498
			8758.26025700349
			8268.9431453179
	7422.02652409522		10432.6224414300
			9531.79896351271
			7018.9715641573
			13562.5053519733
			12214.8148993040
			8516.61557276

Recognized Expression

Test Image	**Distance From Neutral**	**Expression**	**Best Match Of Reference database Image**
Image 003	**7422**	**Sad**	**Image 006**

Table No.5: Experimental Result for Happy Expression

Testing image	**Reference database images**	**Euclidean distance between test expressions and all train expressions.**	**Euclidean distance between test expressions and mean of neutral expressions.**
 Image001	 Image001	13395.4834816726	7236.89435669620
	 Image002	7914.28548308428	
	 Image003	9810.44508204180	
	 Image004	9688.51167546058	
	 Image005	9345.76776092216	
	 Image006	10373.0532329890	
	 Image007	10019.0921044099	
	 Image008	7383.63855477789	
	 Image009	7183.57965060929	

Recognized Expression

Test Image	**Distance From Neutral**	**Expression**	**Best Match Of Train Image**
Image 001	7237	**Happy**	**Image 009**

VI. CONCLUSION

We have implemented a facial expression recognition system using Principal component analysis method. This approach has been studied using image database. In this project the particular method using Principal Component Analysis for facial expression detection was initially started with 3 reference images and 6 testing images from each class of expre-ssion. After that the same procedure was repeated by increasing the number of reference images from each class of expression and decreasing the number of testing images. The principal components are selected for each class independently to reduce the eigenspace. With these eigenvectors the input test images were classified based on Euclidian distance. The proposed method was tested on database of 3 different persons with different expressions. The proposed PCA method has the greater accuracy with consistency. There cognition rate was greater even with the small number of training images which demonstrated that it is fast, relatively simple and works well in a constrained environment.

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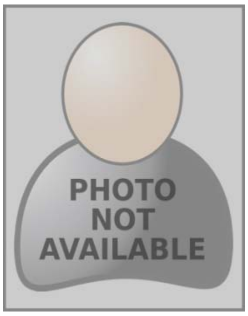

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