Comparative Study of Facial Expression Recognition Techniques

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ABSTRACT
This paper explores and compares techniques for automatically recognizing facial actions in sequences of images.The comparative study of Facial Expression Recognition techniques namely Principal Component analysis (PCA), PCA with SVD (Singular Value Decomposition) is done .The objective of this research is to show that PCA with SVD is superior to former technique in terms of recognition rate .To test and evaluate their performance, experiments are performed using JAFEE and real database using both techniques. The universally accepted five principal emotions to be recognized are: Angry, Happy, Sad, Disgust and Surprise along with neutral. The recognition rate is obtained on all the facial expressions.

Keywords: Facial Expression Recognition, Principle component Analysis (PCA), Recognition Rate, Singular Value Decomposition (SVD), etc.

1. INTRODUCTION
Face recognition is the automated assignment of a digital image to a particular person by analyzing the features of the face in that image. The method of face recognition consists of three components: face detection, image processing and face identification. Face detection uses computer learning to detect the location of any faces within an image. Image processing consists of scaling and image rendering to prepare the face for identification. Face identification uses mathematical techniques on the pixel values or features in the facial area of an image to determine who the face belongs to. The most useful applications contain crowd surveillance, video content indexing, personal identification (ex. driver's license), mug shots matching, entrance security, etc. . We believe recognition of human facial expression by computer is a key to develop such technology. In recent years, much research has been done on machine recognition of human facial expressions Face recognition has been studied extensively for more than 40 years. Now it is one of the most imperative subtopics in the domain of face research [1]-[4]. Face recognition is a technology which recognizes the human by his/her faces image .Recent advances in image analysis and pattern recognition open up the possibility of automatic detection and classification of emotional and conversational facial signals. The goal of this paper is to survey the work done in automating facial expression analysis in facial images and image sequences. The basic problems related to facial expression analysis is: face detection in a facial image or image sequence, facial expression data extraction, and facial expression classification. Our aim is to explore the issues in design and implementation of a system that could perform automated facial expression analysis. In general, three main steps can be distinguished in tackling the problem. First, before a facial expression can be analyzed, the face must be detected in a scene. Next is to devise mechanisms for extracting the facial expression information from the observed facial image or image sequence. In the case of static images, the process of extracting the facial expression information is referred to as localizing the face and its features in the scene. In the case of facial image sequences, this process is referred to as tracking the face and its features in the scene. At this point, a clear distinction should be made between two terms, namely, facial features and face model features. The facial features are the prominent features of the face eyebrows, eyes, nose, mouth, and chin. The face model features are the features used to represent (model) the face. The face can be represented in various ways, e.g., as a whole unit (holistic representation), as a set of features (analytic representation) or as a combination of these (hybrid approach). The applied face representation and the kind of input images determine the choice of mechanisms for automatic extraction of facial expression information.

2. RELATED WORK
Recent approaches include measurement of facial motion through optic flow [2], [4], [8], [9] and analysis of surface textures based on principal component analysis (PCA).In addition, a number of methods that have been developed for representing faces for identity recognition may also be powerful for expression analysis. These approaches are also included in the present comparison. These include Gabor wavelets [17], [20], linear discriminant analysis [8], local feature analysis [14], and independent component analysis [5], [4].Bartlett explores and compares techniques for automatically recognizing facial actions in sequences of images. These techniques include analysis of facial motion through estimation of optical flow; holistic spatial analysis, such as independent component analysis, local feature analysis, and linear discriminant analysis; and methods based on the outputs of local filters, such as Gabor wavelet representations and local principal components[5].Donato compared several techniques, which included optical flow, principal component analysis, independent component analysis, local feature analysis and Gabor wavelet representation, to recognize eight single action units and four action unit combinations using image sequences that were manually aligned and free of head motions[6]. Lien describes a system that recognizes various action units based on dense flow, feature point tracking and edge extraction. The system includes three modules to extract feature information: dense-flow extraction using a wavelet motion model, facial feature tracking, and edge and line extraction [7]. Fasel fulfills the recognition of facial action units, i.e., the subtle change of facial expressions, and emotion-specified expressions. The optimum facial feature extraction algorithm, Canny Edge Detector, is applied to localize face images, and a hierarchical clustering-based scheme reinforces the search region of extracted highly textured facial clusters[8].This paper provides a new fully automatic framework to analyze facial action units, the fundamental building blocks of facial expression enumerated in Paul Ekman's Facial Action Coding System (FACS). The action units examined in this paper include upper facial muscle movements such as inner eyebrow raise, eye widening, and so forth, which combine to form facial expressions[9].In this paper, **a** new technique coined two-dimensional principal component analysis (2DPCA) is developed for image representation. As opposed to PCA, 2DPCA is based on 2D image matrices rather than 1D vector. But after 2DPCA, PCA must be applied which is

unrealistic in such situation [19]. Lee and Kim [14] approached a method of expression-invariant face recognition that transforms input face image with an arbitrary expression into its corresponding neutral facial expression image. To achieve expression-invariance, first extract the facial feature vector from the input image using AAM. Next, transform the input facial feature vector into its corresponding neutral facial expression vector using direct or indirect facial expression transformation. Finally, perform the expression-invariant face recognition by distance-based matching techniques nearest neighbor classifier, linear discriminant analysis (LDA) and generalized discriminant analysis (GDA). Geetha et al. [11] a method was described for real time face/head tracking and facial expression recognition. A face is located by extracting the head contour points using the motion information. Among the facial features, eyes are the most prominent features used for determining the size of a face. The visual features are modeled using support vector machine (SVM) for facial expression recognition.

3. FACIAL EXPRESSION DATABASE

3.1 PCA

The databases used for Facial Expression Recognition using PCA are JAFEE and Essex database. In JAFEE database, there are 7 test images and 7 train images. Each image has been rated on 6 emotions. All images are resized to a uniform dimension of 256 x 256.

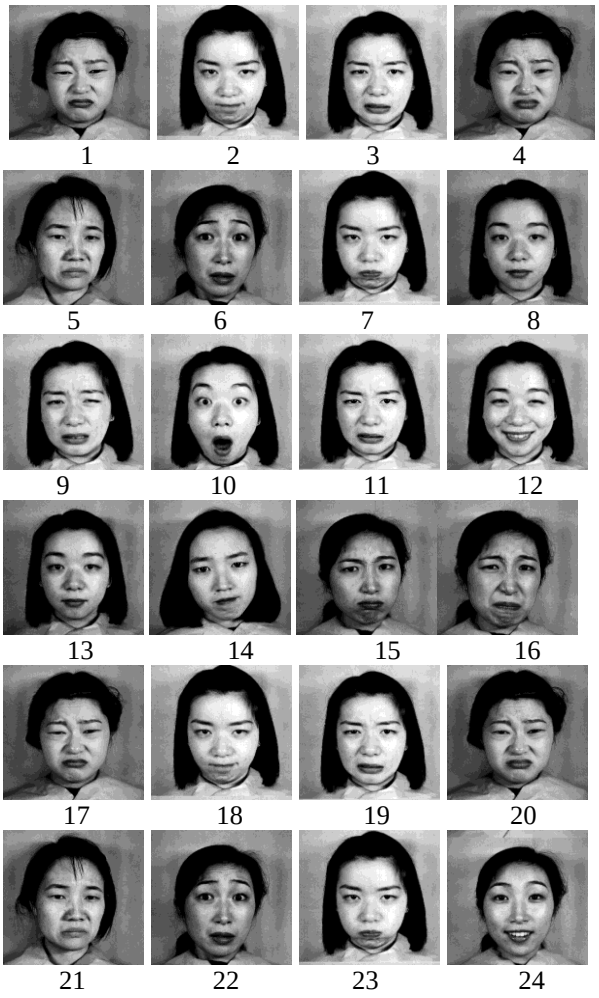

Fig 1:24 Test Images in JAFEE database

3.2 PCA with SVD

The two databases used for facial expression system is JAFEE and Real Database. There are 31 test images and 50 train images in JAFEE Database and Real database. All images are resized to a uniform dimension of 256 x 256. Each image has been rated on 6 emotions. Following Figures shows the database test images considered for face Expression recognition.

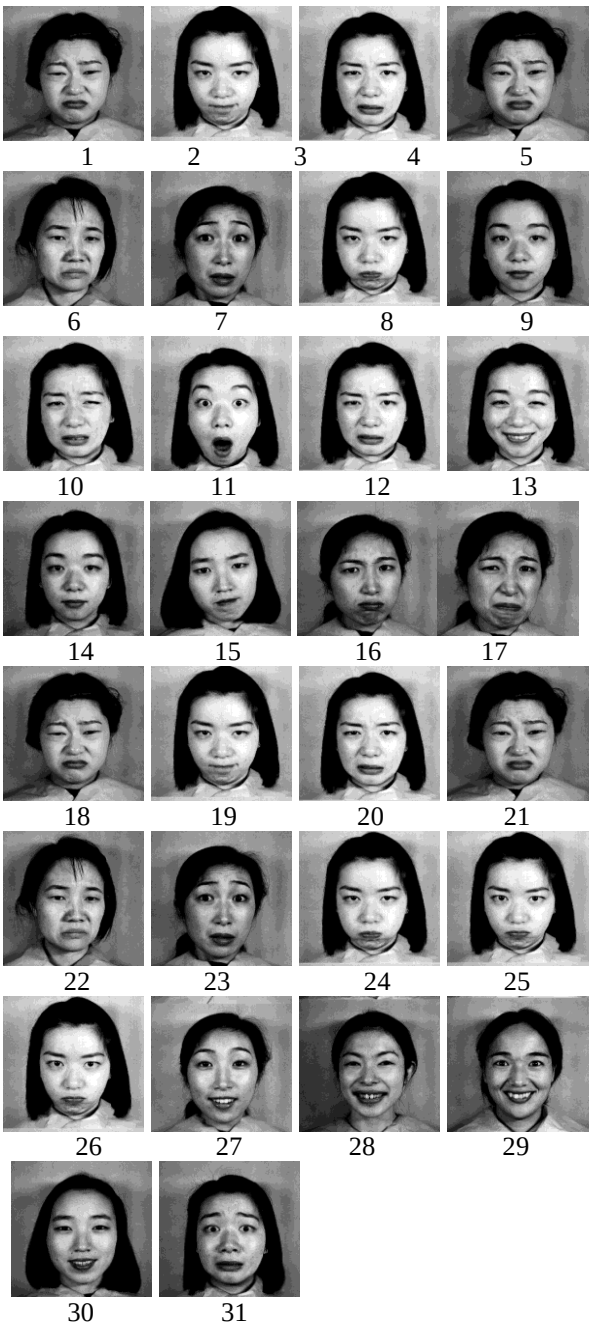

Fig 2: 31 Test Images of Individual in Jafee database

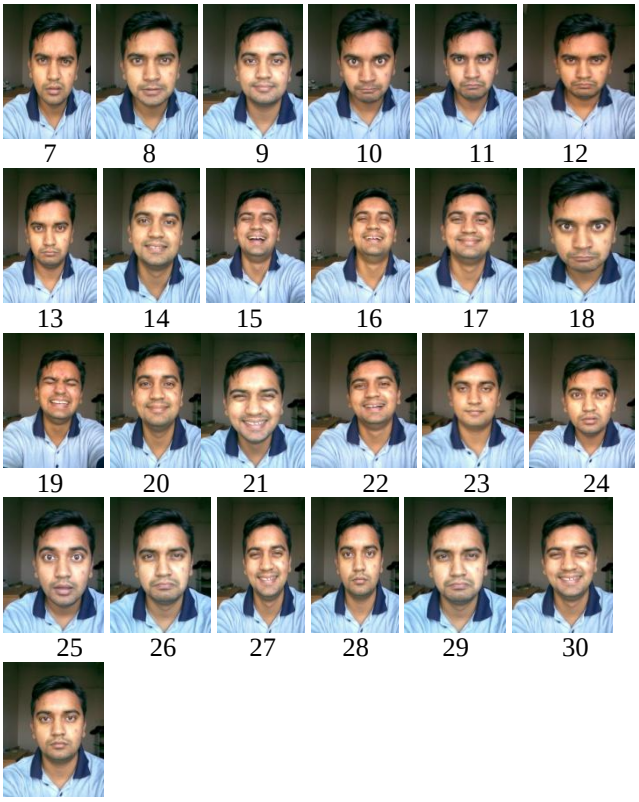

Fig 3: 31Test Images of Individual in Real Database

4. PRINCIPAL COMPONENT ANALYSIS (PCA) AND SINGULAR VALUE DECOMPOSITION (SVD)

Principal Component Analysis (PCA) is a statistical technique used for dimension reduction and recognition, & widely used for facial feature extraction and recognition. PCA is known as Eigen space Projection which is based on linearly Projection the image space to a low dimension feature space that is known as Eigen space. Many PCA-based face-recognition systems have also been developed in the last decade. However, existing PCA-based face recognition systems are hard to scale up because of the computational cost and memory-requirement burden. A 2-D facial image can be represented as 1-D vector by concatenating each row (or column) into a long thin vector. Let's suppose we have M vectors of size N (= rows of image £ columns of image) representing a set of sampled images. pj's represent the pixel values.

$x_i = [p_1,p_N]^T$; i = 1,.....,M

The images are mean centered by subtracting the mean image from each image vector. Let m represent the mean image.

$$m = 1/M \sum_{i=1}^{M} x_i$$

And let w_i be defined as mean centered image

$w_i = xi - m$

Our goal is to find a set of e_i's which have the largest possible projection onto each of the w_i's.

4.1 Singular Value Decomposition

The singular value decomposition is an outcome of linear algebra. It plays an interesting, fundamental role in many different applications. On such application is in digital image processing. SVD in digital applications provides a robust method of storing large images as smaller, more manageable square ones. This is accomplished by reproducing the original image with each succeeding nonzero singular value. Furthermore, to reduce storage size even further, images may approximate using fewer singular values. The singular value decomposition of a matrix A of m x n matrix is given in the form,

$$A=U\Sigma V^T$$

Where U is an m x m orthogonal matrix; V an n x n orthogonal matrix, and ∑ is an m x n matrix containing the singular values of A along its main diagonal. The singular values

$\alpha_1\ \alpha_2$……, α_n are unique, however, the matrices U and V are not unique A similar technique, known as the Eigen value decomposition (EVD) also called Principal Component Analysis (PCA) digitalizes matrix A, but with this case, A must be a square matrix. The EVD digitalizes an as in equation Where D is a diagonal matrix comprised of the Eigen values, and V is a matrix whose columns contain the corresponding eigenvectors. Where Eigen value decomposition may not be possible for all facial images, SVD is the result.

5. IMPLEMENTATION

The block schematic of facial expression recognition system isgiven in Figure: 4 .Test Image is acquired and preprocessed to uniform dimension. Then Features are extracted in Feature Extraction unit and given to Classifier unit for identification with features extracted from knowledge database. Finally recognized expression is given as output.

5.1 Implementation on JAFEE using PCA

We have experimented on 24 test images of different facial expressions from JAFEE. There are 24 test images in testing dataset which are compared with 10 train images in training dataset to recognize facial expressions. The images are of uniform dimensions of 256x256 sizes.

5.2 Implementation on JAFEE and Real Database using PCA and SVD

We have experimented on 31 test images of different facial expressions from JAFEE and Real database. There are 31 test images in training dataset which are compared with 50 train images in training dataset to recognize facial expressions. The images are of uniform dimensions of 256x256 sizes. The facial expression database is maintained of all the 50 train images which consist of Train image name and its facial expression. Table 1shows the facial expression database of JAFEE. The images in Test and train database are converted from RGB to Gray in case of Real database. The training and testing data is loaded. The quality of test and train images is enhanced by the removal of noise if present in these images. Test and Train images are cropped. Then singular values are calculated of both train images and test images. Facial feature matrices are built of the singular values. The test data is loaded and projected on the feature space. The Feature matrices of train images and testing images are passed to the classifier unit for the classification of given face query with the knowledge created for the available database. Then Euclidean distance based matching Classifier is used for finding the closest match. The mean of neutral images is calculated of train images. Then distance between the expression of test image and mean neutral expression is calculated which is Euclidean distance. Similarly, distance between the expression of train image and mean neutral expression is calculated. The minimum difference between any pair would symbolize the best possible matched facial Expression. In the end, a text file is generated which shows the test image name, its Euclidean distance, recognized expression and train image name.

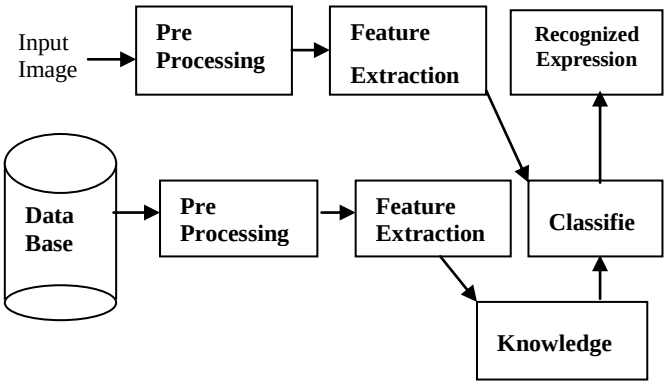

Fig 4: Methodology of Facial Expression recognition

6. RESULTS

The optimally design Principal Component Analysis with Singular Value Decompositions is tested on the training dataset. The results obtained are excellent. We got 100% recognition for all five principal emotions namely Angry, Disgusts, Happy, Sad and Surprise along with Neutral.

6.1 Results Obtained on JAFEE Database using PCA

The Test image is input and its equivalent recognized image is obtained. Recognition rate is than 100% for all principal emotions.

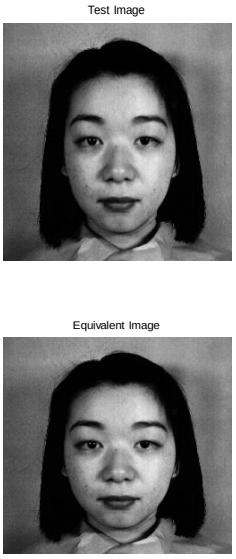

Fig 5:Results obtained on PCA

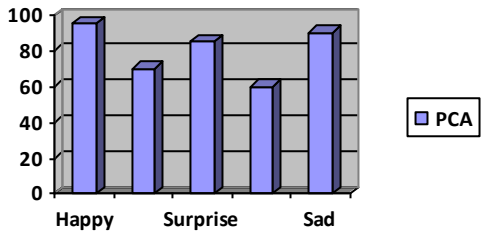

Fig 3: Recognition Rate of various Facial Expressions Represented using PCA on Bar Chart

6.2 Results Obtained on JAFEE Database using PCA and SVD

The Image Size is plotted in Figure 5 which shows that all the images considered are of size 256x256.Figure 6 shows the plot of Mean image and mean neutral. Figure 7 shows the plot of distance of test image from neutral images.

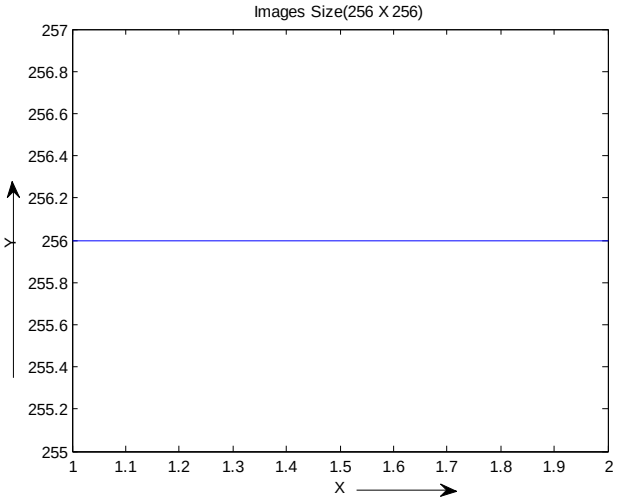

Fig 5: Image Size in JAFEE and Real Database

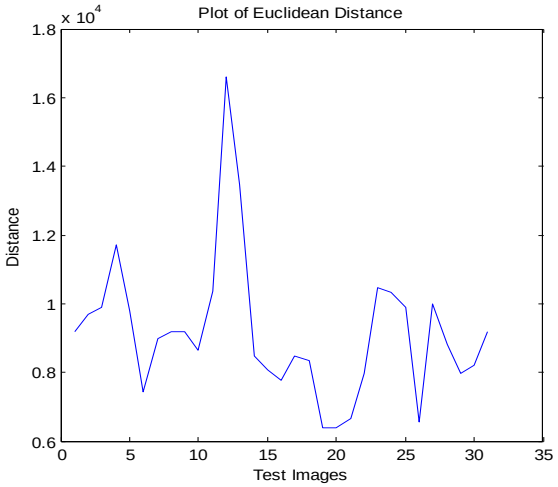

Fig 6: Euclidean Distance calculated of 31 Test Images

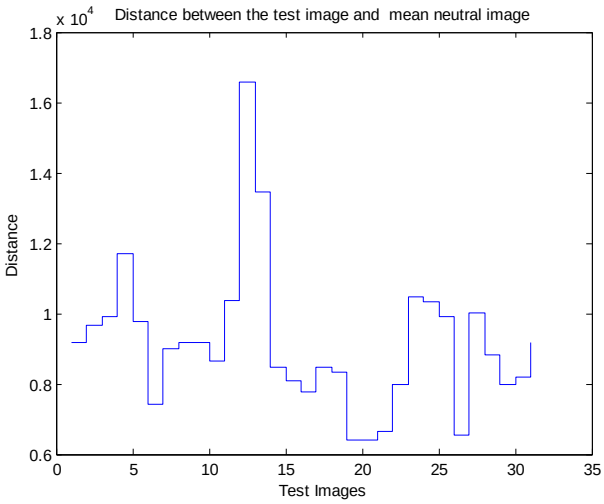

Fig 7: Distance between Test image and Mean Neutral image

Table 1: Facial Expression Database maintained in JAFEE Database

Train Image in JAFEE	Expression
Image001.jpg	happy
Image002.jpg	happy
Image003.jpg	happy
Image004.jpg	happy
Image005.jpg	happy
Image006.jpg	happy
Image007.jpg	happy
Image008.jpg	happy
Image009.jpg	happy
Image010.jpg	happy
Image011.jpg	happy
Image012.jpg	happy
Image013.jpg	happy
Image014.jpg	disgust
Image015.jpg	disgust
Image016.jpg	disgust
Image017.jpg	disgust
Image018.jpg	disgust
Image019.jpg	disgust
Image020.jpg	disgust
Image021.jpg	disgust
Image022.jpg	disgust
Image023.jpg	disgust
Image024.jpg	disgust
Image025.jpg	anger
Image026.jpg	anger
Image027.jpg	anger
Image028.jpg	anger
Image029.jpg	surprise
Image030.jpg	surprise
Image031.jpg	surprise
Image032.jpg	anger
Image033.jpg	anger
Image034.jpg	anger
Image035.jpg	sad
Image036.jpg	sad
Image037.jpg	sad
Image038.jpg	sad
Image039.jpg	sad
Image040.jpg	sad
Image041.jpg	sad
Image042.jpg	sad
Image043.jpg	sad
Image044.jpg	neutral
Image045.jpg	neutral
Image046.jpg	neutral
Image047.jpg	neutral
Image048.jpg	neutral
Image049.jpg	neutral
Image050.jpg	neutral

Table 2: Facial Expression Recognition Results Obtained on JAFEE Database

Jaffe Test Image	Distance From Neutral	Expression	Best Possible Match
Image001.tiff	9174	disgust	Image020.tiff
Image002.tiff	9679	disgust	Image024.tiff
Image003.tiff	9895	neutral	Image047.tiff
Image004.tiff	11706	neutral	Image048.tiff
Image005.tiff	9786	disgust	Image024.tiff
Image006.tiff	7436	neutral	Image044.tiff
Image007.tiff	8987	happy	Image006.tiff
Image008.tiff	9174	disgust	Image020.tiff
Image009.tiff	9174	disgust	Image020.tiff
Image010.tiff	8641	happy	Image008.tiff
Image011.tiff	10353	happy	Image001.tiff
Image012.tiff	16590	happy	Image002.tiff
Image013.tiff	13452	neutral	Image048.tiff
Image014.tiff	8484	sad	Image041.tiff
Image015.tiff	8081	disgust	Image014.tiff
Image016.tiff	7759	happy	Image004.tiff
Image017.tiff	8484	sad	Image041.tiff
Image018.tiff	8338	neutral	Image046.tiff
Image019.tiff	6402	anger	Image029.tiff
Image020.tiff	6402	anger	Image029.tiff
Image021.tiff	6665	anger	Image029.tiff
Image022.tiff	7972	disgust	Image022.tiff
Image023.tiff	10464	anger	Image034.tiff
Image024.tiff	10347	anger	Image034.tiff
Image025.tiff	9895	neutral	Image047.tiff
Image026.tiff	6541	anger	Image029.tiff
Image027.tiff	10005	neutral	Image047.tiff
Image028.tiff	8809	anger	Image033.tiff
Image029.tiff	7972	disgust	Image022.tiff
Image030.tiff	8204	happy	Image010.tiff
Image031.tiff	9174	disgust	Image020.tiff

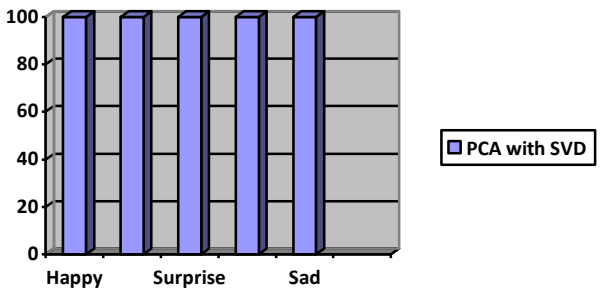

Fig 8: Recognition Rate of various Facial Expressions Represented on Bar Chart of JAFEE Database

6.3 Results Obtained on Real Database using PCA and SVD

The Eigen Faces are obtained of all the Images in Test and Train Database.The Image Size is plotted in Figure 5 above which shows that all the images considered are of uniform size 256x256. Figure 9 shows the plot of Euclidean distance

calculated of 31Test Images of Real database. Fig 10 shows the Recognition Rate of various Facial Expressions of test images represented on Bar Chart.

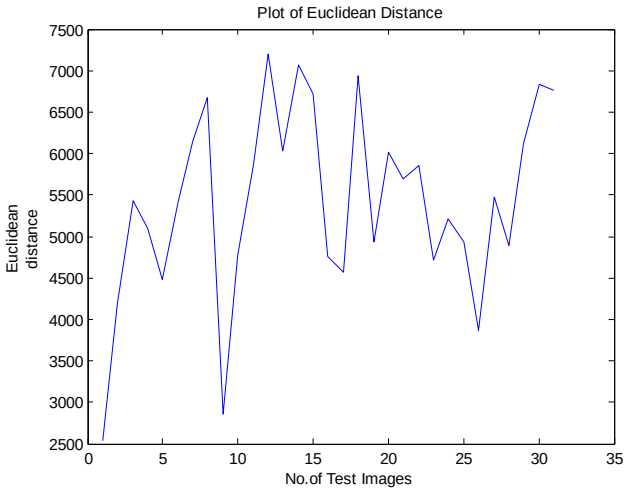

Fig 9: Plot of Euclidean distance calculated of 31Test Images of Real database

Table 3: Facial Expression Database of Train images in Real Database

Train Image in JAFEE	Expression
Image001.jpg	Happy
Image002.jpg	Happy
Image003.jpg	Happy
Image004.jpg	Happy
Image005.jpg	Happy
Image006.jpg	Happy
Image007.jpg	Happy
Image008.jpg	Happy
Image009.jpg	Happy
Image010.jpg	Happy
Image011.jpg	Happy
Image012.jpg	Happy
Image013.jpg	Happy
Image014.jpg	Disgust
Image015.jpg	Disgust
Image016.jpg	Disgust
Image017.jpg	Disgust
Image018.jpg	Disgust
Image019.jpg	Disgust
Image020.jpg	Disgust
Image021.jpg	Disgust
Image022.jpg	Disgust
Image023.jpg	Disgust
Image024.jpg	Disgust
Image025.jpg	Anger
Image026.jpg	Anger
Image027.jpg	Anger
Image028.jpg	Anger
Image029.jpg	Surprise
Image030.jpg	Surprise
Image031.jpg	Surprise
Image032.jpg	Anger
Image033.jpg	Anger
Image034.jpg	Anger
Image035.jpg	Sad
Image036.jpg	Sad
Image037.jpg	Sad
Image038.jpg	Sad
Image039.jpg	Sad
Image040.jpg	Sad
Image041.jpg	Sad
Image042.jpg	Sad
Image043.jpg	Sad
Image044.jpg	Neutral
Image045.jpg	Neutral
Image046.jpg	Neutral
Image047.jpg	Neutral
Image048.jpg	Neutral
Image049.jpg	Neutral
Image050.jpg	Neutral

Table 4: Facial Expression Recognition Results Obtained In Real Database

Test Image In Real Database	Distance From Neutral	Facial Expression	Best Possible Match in Training Database
Image001.jpg	2535	neutral	Image046.jpg
Image002.jpg	4190	happy	Image008.jpg
Image003.jpg	5435	disgust	Image014.jpg
Image004.jpg	5097	surprise	Image029.jpg
Image005.jpg	4487	anger	Image025.jpg
Image006.jpg	5416	happy	Image003.jpg
Image007.jpg	6154	sad	Image041.jpg
Image008.jpg	6675	happy	Image010.jpg
Image009.jpg	2852	neutral	Image046.jpg
Image010.jpg	4773	happy	Image008.jpg
Image011.jpg	5864	sad	Image040.jpg
Image012.jpg	7205	surprise	Image031.jpg
Image013.jpg	6027	happy	Image006.jpg
Image014.jpg	7075	happy	Image012.jpg
Image015.jpg	6718	happy	Image006.jpg
Image016.jpg	4755	sad	Image040.jpg
Image017.jpg	4569	neutral	Image046.jpg
Image018.jpg	6938	disgust	Image022.jpg
Image019.jpg	4939	disgust	Image022.jpg
Image020.jpg	6012	anger	Image026.jpg
Image021.jpg	5700	disgust	Image021.jpg
Image022.jpg	5852	disgust	Image021.jpg
Image023.jpg	4710	disgust	Image018.jpg
Image024.jpg	5211	disgust	Image022.jpg
Image025.jpg	4940	disgust	Image023.jpg
Image026.jpg	3865	neutral	Image049.jpg

Image027.jpg	5473	disgust	Image016.jpg
Image028.jpg	4883	disgust	Image023.jpg
Image029.jpg	6111	surprise	Image029.jpg
Image030.jpg	6836	disgust	Image022.jpg
Image031.jpg	6756	surprise	Image029.jpg

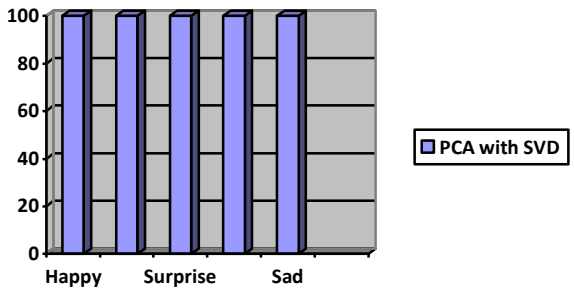

Fig 10: Recognition Rate of various Facial Expressions Represented on Bar Chart of Real Database

7. COMPARISON OF PCA &PCA WITH SVD

The comparison on the basis of various characteristics is given in the table below of PCA and PCA with SVD. This shows that PCA with SVD is superior to former technique in terms of its recognition rate and various other properties.

Table 5: Comparison of facial expression recognition techniques

CHARACTERSTICS	PCA	PCA WITH SVD
DIMENSIONAL REDUCTION	HIGH	HIGHER THAN PCA
RECOGNITION RATE	LESS THAN 100%	100%
SINGULAR VALUES	EIGENVAUES ARE CALCULATED DIRECTLY	YES,CALCULATED
PRINCIPAL COMPONENTS	YES,FROM COVARIANCE MATRIX5	YES,CALCULATED FROM SINGULAR VALUES
NOISE REMOVAL	NO	YES
MEMORY REQUIREMENTS	MORE	LESS THAN PCA
MATHEMATICAL FORM	$A=U\sum U^T$	$A=U\sum V^T$
COMPUTATION TIME	LESS	MORE
NUMERICAL PROPERTIES	GOOD	BETTER THAN PCA

8. CONCLUSION

In this research paper comparative study of PCA for classification of emotion using Singular Value Decomposition and PCA is done. We achieved 100% result for all principal emotions along with Neutral on training dataset using PCA with SVD. The implementation is done on both real database as well as JAFFE database. Experimental results show that algorithm can effectively distinguish different Expressions by identifying features. The results show that PCA with SVD is superior to PCA in terms of recognition rate .Each image is enhanced, localized and its features are extracted using PCA with SVD. Future work consists three aspects, one is to work on more complex image such as vary large size 2D image or 3D images with SVD technique for image compression and recognition; second, deeply to study and investigate the roles of singular values andSingular vectors in image processing. Third, this application is completed on the MATLAB, in the future; the application can be performed with programming of Java or C++.

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