Face Recognition Using Singular Value Decomposition of Facial Colour Image Database

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Abstract: *Face recognition system should be able to automatically detect a face in images. This involves extraction of its features and then recognizes it, regardless of lighting, ageing, occlusion, expression, illumination and pose. The Singular Value Decomposition and Principal Component Analysis are very useful techniques in data analysis and visualization. Singular Value Decomposition approach used in image compression and face recognition. In this paper we have attempted a comparative study of Singular Value Decomposition. The first experiment is used standard face95 and face96 Database. The performance of SVD is 100%. The second experiment is used standard grimances database. Two different classes are tested using SVD and its performance is 100%.The experiment is also tested for locally created poor image quality database and pose variation database and its recognition performance is 100%.*

Keywords: Face Recognition, Singular Value Decomposition, Pattern Recognition, Image Processing, Colour Image, Biometric

1. Introduction

Automatic recognition of faces is considered as one of the fundamental problems in computer vision and pattern recognition. Face Recognition is widely used in biometric systems. Face Recognition by human being is very easy but it is very difficult to computer. The difficulties in face recognition are different poses, expressions, illuminations, orientations and presence of glasses. Face recognition is also useful in human computer interaction, virtual reality, database retrieval, multimedia, computer entertainment, information security e.g. operating system, medical records, online banking., biometric e.g. personal identification - passports, driver licenses , automated identity verification – border controls , law enforcement e.g. video surveillances , investigation , personal security – driver monitoring system, home video surveillance system. Great progress has been made in the area of machine recognition and many methods have been implemented [1-4]. This paper [5], provides an up-to-date critical survey of still- and video-based face recognition research. In this paper [6], focuses on the algebraic features are stable and valid features in object recognition such as face recognition. He proposed singular value decomposition (SVD) based method which uses the singular values as the feature extractor and had obtained an acceptable recognition rate. This paper [7], presents an algorithm for face recognition by performing singular valued decomposition on the extracted feature of images and then training were done using back propagation neural network where the ORL database of faces were used. In this paper [8], we proposed a novel method for face recognition. This method combines the advantages of the recent LDA enhancements namely relevance weighted LDA and singular value decomposition and also reduces dimensions of input data matrix using 2DLDA concept. In this paper [9], focuses on the principal component analysis (PCA) is implemented with Singular value decomposition for feature extraction to

determine principal emotions. In this paper [10], recognition is performed on a uniform eigen-space of Singular Value Decomposition of the enhanced image set. In this paper [11], we first study the role of SVD and FFT in both filed. Then the decomposition information from SVD and FFT are compared. In this paper [12], we studied singular value decomposition based JPEG image compression technique.

2. Singular Value Decomposition

The Singular value decomposition is an outcome of linear algebra. It plays an interesting, fundamental role in many different applications that is, face recognition, image compression, watermarking, object detection, scientific computing, signal processing, texture classification etc. The special feature of SVD is that it can be performed on any real matrix. The singular value decomposition of a rectangular matrix A is a decomposition of the form

$$A = USV^T \quad (1)$$

Where A is an m x n matrix, U = m x m and V = n x n. U and V are orthogonal Matrices. *A square matrix A with real entries and satisfying the condition $A^{-1} = A^t$ is called an orthogonal matrix.* S is an m x n diagonal matrix with singular values on the diagonal.

$$AA^T = USV^T (USV^T)^T$$
$$= USV^TVSU^T$$
$$= US^2U^T$$
also

$$A^TA = (USV^T)^T USV^T$$
$$= VSU^TUSV^T$$
$$= VS^2V^T$$

Thus U and V are calculated as the eigen vectors of AA^T and A^TA respectively. The square root of the eigen values are the

singular values along the diagonal of the matrix S. If the matrix A is real, then the singular values are always real numbers, and U and V are also real.

2.1 Properties of SVD

1. The singular values σ_1, σ_2……. σ_n are unique, however the matrix U and V are not unique.
2. $AA^T = USV^T$ ($USV^T)^T = USV^TVSU^T = US^2U^T$ hence V diagonlises A^TA. It follows that the matrix V can be computed through the eigen vector of A^TA
3. The matrix U can be computed through the eigen vector of AA^T
4. The rank of the matrix A is equal to the number of its non-zero singular values.

3. The steps in finding Singular Value Decomposition [13] as follows:

1. Get a dataset in S with N images.
2. Calculate the mean of S and store into imgm

$$imgm = \frac{1}{N}\sum_{i=1}^{N} Si \qquad (1)$$

3. Subtract imgm from the original faces S_i gives

$$A = Si - imgm \; Where \; i = 1,2,3,4\ldots\ldots N$$

4. Calculate the Singular Value Decomposition of A as shown in (1), obtain U,S and V. that is U is m x m right side matrix of singular value decomposition of matrix A m x n, S is an m x n diagonal matrix with singular values on the diagonal and V is n x n left side matrix of singular value decomposition of matrix A m x n.
5. Choose Singular Value range that is SV
6. Usv is m x SV matrix that are form from U.
7. Multiply A with transpose of Usv and assign to X,

$$X = Usv' * A$$

8. Get the query image

9. Subtract query image from imgm and assign to qimgm.
10. Multiply qimgm with transpose of Usv and assign to

$$x = Usv' * qimgm$$

11. Subtract x from X

$$(D = X - x * ones(1,N))$$

12. Multiply D with transpose of D, Select diagonal of multiplied matrix and calculate square root of diagonal.
13. Select minimum of square root and compare with threshold value, if selected minimum value is less than threshold then query image is face otherwise query image is an unknown face image. In the above algorithm variables imgm, qimgm used to stored image mean and query image mean.

4. Image Database

The experiments were done using Singular Value Decomposition of facial color image database. The images were obtained from Libor Spacek Collection of facial images [16]. This database includes 7900 colored images of faces of 395 individuals. Each individual has 20 image samples in the database. The database consisits of male and female images of various racial origins. The images are mainly of first year undergraduate students, so the majority of individuals are between 18-20 years old but some under individuals are alsopresent. Some of the individuals has glasses and some of the male individuals have beards. The image format is 24-bit color jpeg in other words 200 x 180 array of pixels and each pixel isrepresented by 24 bits of RGB color values. The image were recorded with an S-VHS camcorder camera and the lighting is artificial, mixture of tungsten and fluorescent overhead.

4.1 Experiment I

Experiment were conducted standard face95 and face96 database. The face95 database contains number of individuals 72. The background consists of a red curtain. Background variation is caused by shadows as subject moves forward. Large head scale and some expression variation. The face96 database contains number of individuals 152. The background is complex (glossy poster). Large headscale and some expression variation. The position of face in image is some translation. All images have same size and the extension of these images jpeg.The **20** and **9** face images in the database were tested using singular value decomposition. The threshold values of all database is changed.

The **figure 1** shows the sample images of face95 database. The **figure 2** shows the graph of singular values of face95 database and **figure3** gives the query and output image. The **figure 4** shows the sample images of face96 database. The **figure 5** shows the graph of singular values of face96 database and **figure 6** gives the query and output image. The Success rate of recognition using Singular Value Decomposition is 100%.The Table 1 shows the Singular Value Decompostion performace.
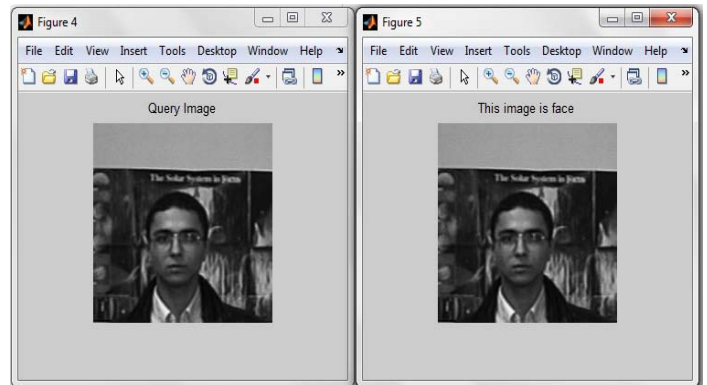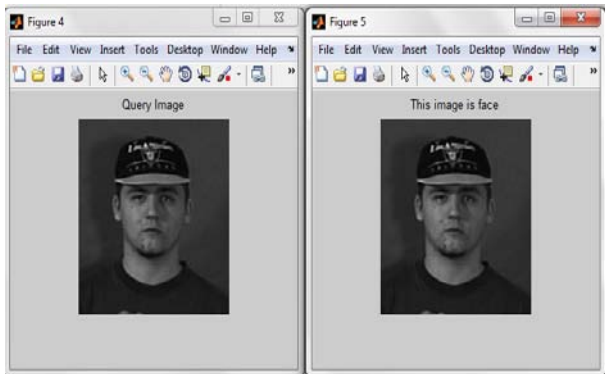
5. Result

Figure 1: Sample Images of face95 database
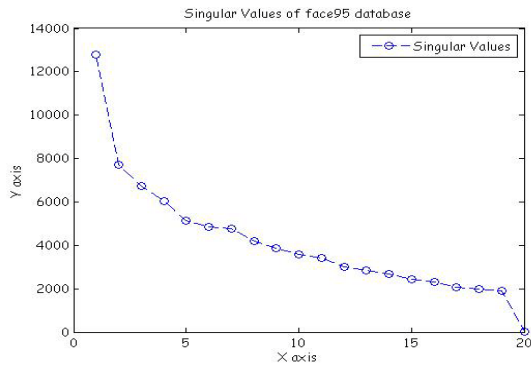
Figure 2: Singular Values of face95 database graph

Figure 3: Query and Output Image face95 database

Figure 4: Sample Images of face96 database

Figure 5: Singular Values of face96 database graph

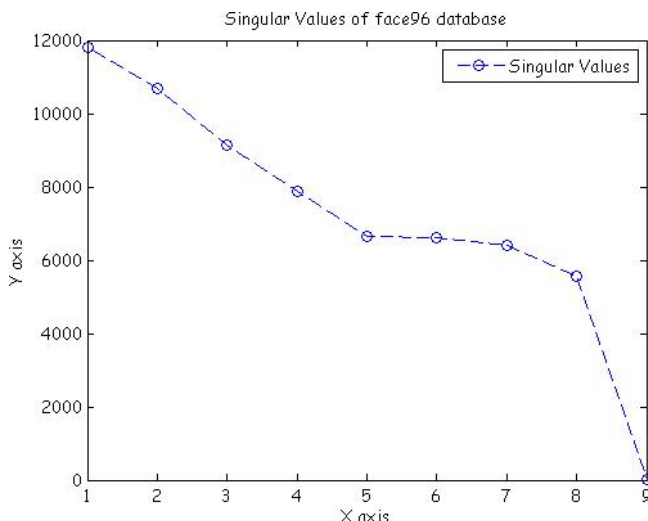**Figure 6:** Query and Output Image face96 database

4.2 Experiment II

Experiment was conducted on Grimance, local and pose variation database. The Grimance database contains 18 individuals. The image resolution is 180x200 pixels. The content of images of male and female. The background of images is plain in which there are small head scale variation. The lighting variation is very little. The major expression variation was the two different classes are tested using singular value decomposition. The five images, there is no expression and same five images of some expression variation.

The local images is created by Digital Camera. The image format is color jpeg. The dimensions of these images 240 x 180 pixel. The pose variation database is created by Sony (5.1 mp) Digital Camera. The image format is color jpeg. The dimensions of these images 320 x 240 pixel. These database is available on website http://dsmcsresearch.info.

The **10**, **10** and **5** face images in the database were tested using singular value decomposition. The threshold values of all database is changed.The **figure 7** shows the sample images of two different classes for grimace database.The **figure 8** shows the graph of singular values of grimance database and **figure 9** gives the query and output image.

The **figure 10** shows the sample images of two different classes for local database. The **figure 11** shows the graph of singular values of local database and **figure 12** gives the query and output image. The **figure 13** shows the sample images of two different classes for pose variations database. The **figure 14** shows the graph of singular values of pose variations database and **figure 15** gives the query and output image. The success rate of recognition using Singular Value Decomposition is 100%.**The Table 1 shows the Singular Value Decompostion performace.**

6. Result

Figure 7: Sample Images of two different classes

Figure 10: Sample Images of local database
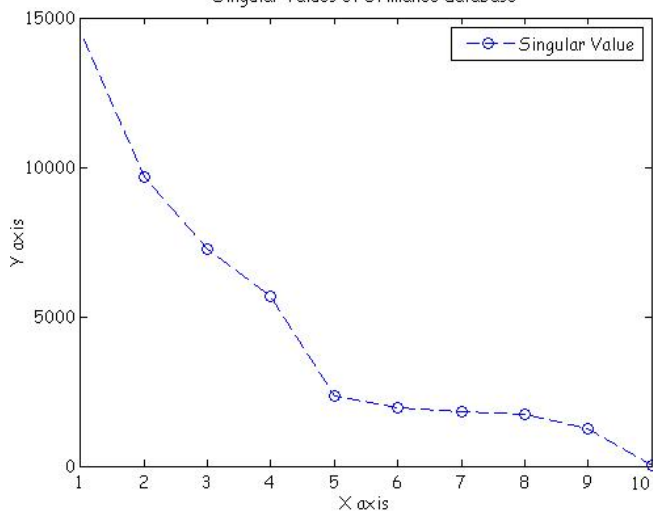
Figure 8: Singular Values of Grimance database graph

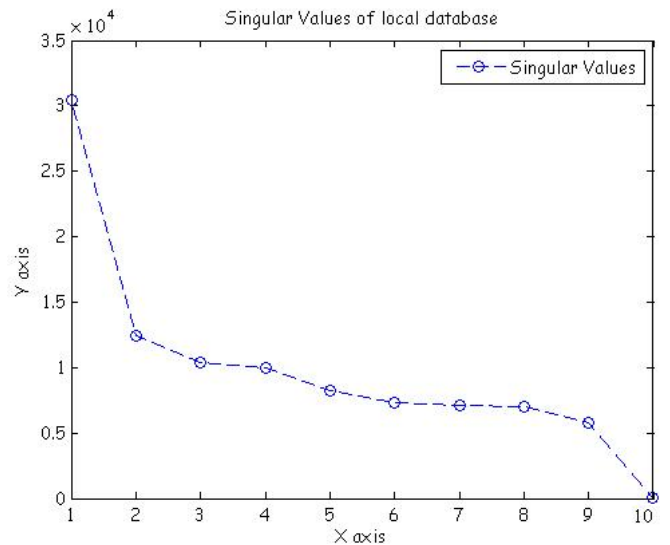**Figure 11:** Singular Values of local database graph

Figure 9: Query and Output Image Grimance Database
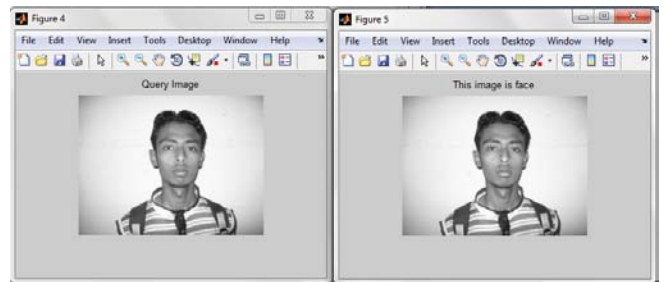
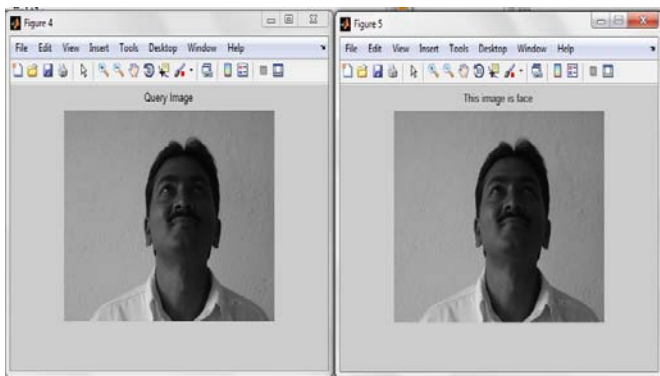**Figure 12:** Query and Output Image local Database

Figure 13: Sample Images of Pose Variations database
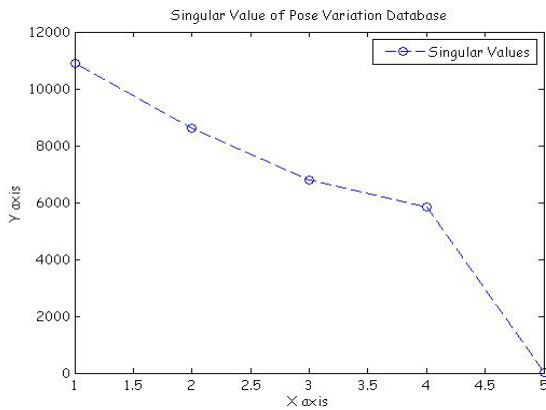
Figure 14: Singular Values of Pose Variations database graph

Figure 15: Query and Output Image Pose Variations Database

Table 1: Singular Value Decomposition Performance

Database	Method	Tested Image	Threshold Value	Recognition (Percentage)
Face 95	SVD	20	2.9500e+003	100
Face 96		9	6.3787e+003	100
Grimace		10	5.8029e+003	100
Local Database		10	7.5035e+003	100
Pose Variation Database		5	3.5013e+003	100

7. Conclusion

Face Recognition Using Singular Value Decomposition of Facial Colour Image Database is implemented in MATLAB. The Singular Value Decomposition is very useful techniques in data analysis and visualization. In this paper we have attempted a comparative study of Singular Value Decomposition. The first experiment is used standard face95 and face96 Database. The performance of SVD is 100%. The second experiment is used standard grimances database. Two different classes are tested using SVD and its performance is 100%.The experiment is also tested for locally created poor image quality database and pose variation database and its recognition performance is 100%.

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