Comparative Analysis of Face Recognition Algorithms for Medical Application

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Abstract — Biometric-based techniques have emerged for recognizing individuals authenticating people. In the field of face recognition, plastic surgery based face recognition is still a lesser explored area. Thus the use of face recognition for surgical faces introduces the new challenge for designing future face recognition system. Face recognition after plastic surgery can lead to rejection of genuine users or acceptance of impostors. Transmuting facial geometry and texture increases the intra-class variability between the pre- and post-surgery images of the same individual. Therefore, matching post-surgery images with pre-surgery images becomes a difficult task for automatic face recognition algorithms. This paper deals with testing of two popular face recognition algorithms on plastic surgery database such as PCA and LDA and compared this algorithms based on Recognition Rate for better performance. Finally, the results are concluded.

Keywords- Principal Component Analysis, Linear Discriminant Analysis, Eigenfaces, Fisherfaces , Plastic Surgery.

I. INTRODUCTION

Over the past few years, the user authentication is increasingly important because the security control is required everywhere. Traditionally, ID cards and passwords are popular for authentication. Recently, biological authentication technologies across voice, iris, fingerprint, palm print, and face, etc are playing a crucial role and attracting intensive interests for many researchers. Among them, plastic surgery based face recognition is still a lesser explored area. Plastic surgery is generally used for improving the facial appearance for example, removing birth marks, moles, scars and correcting disfiguring defects. However, it can also be misused by individuals to conceal their identities with the intent to commit fraud or evade law enforcement. Facial aging is a biological process that leads to gradual changes in the geometry and texture of a face. Unlike aging, plastic surgery is a spontaneous process that is generally performed contrary to the effect of facial aging. On the other hand, disguise is the process of concealing one's identity by using makeup and

other accessories. Variations caused due to disguise are temporary and reversible; however, variations caused due to plastic surgery are long-lasting and may not be reversible. Even the widespread acceptability in the society encourages individuals to undergo plastic surgery for cosmetic reasons. According to the statistics provided by the American Society for Aesthetic Plastic Surgery for year 2010 [1], there is about 9% increase in the total number of cosmetic surgery procedures, with over 500, 000 surgical procedures performed on face. In this section, we analyze the effects of different plastic surgery procedures on face appearance.

- **Changes in skin texture:**
  Some plastic surgery makes people look younger or more attractive by removing face scars, acnes or taking skin resurfacing. As a result, the skin texture will change.
- **Changes of face component:**
  The main face components: forehead, eyelid, nose, lip, chin and ear can be reshaped or restructured by plastic surgery. The local skin texture around the face component may also be disturbed.
- **Changes of global face appearance:**
  Global facial plastic surgery will change the global face appearance, in other words, not only part of the face component and the skin texture will change, but also the whole face geometric structure and appearance will be disturbed.

II. PRINCIPAL COMPONENT ANALYSIS

Research in automatic face recognition started in 1960's, Kirby and Sirovich were among the first to apply Principal Component Analysis (PCA). Turk and pentland popularized the use of PCA for face recognition. PCA is a dimensionality reduction technique that is used for image recognition and compression. It is also known as Karhunen-Loeve transformation

(KLT) or Eigen space projection. The primary focus of the Principal Component Analysis is a standard technique which is commonly used for data reduction in statistical pattern recognition and signal processing. The PCA technique converts a two dimensional image into a one dimensional vector. This vector is then decomposed into uncorrelated principal components (known as Eigen faces) in other words, the technique selects the features of the image which vary the most from the rest of the image. Each face image is represented as a weighted sum (feature vector) of the principal components, which are stored in a one dimensional array. The probe image is compared against a gallery image by measuring the distance between their respective feature vectors. For PCA the probe image must be similar to the gallery image in terms of size, pose and illumination.

A. Eigenfaces

The Eigen face is the first successful technique of face recognition. The Eigen face method uses PCA to linearly project the image space to a low dimensional feature space called Eigen face approach. Basically, eigen face is the eigenvector obtained from PCA. In face recognition, each training image is transformed into a vector by row concatenation. The covariance matrix is constructed by a set of training images. This idea is first proposed by Sirovich and Kirby. After that, Turk and Pentland developed a face recognition system using PCA. The significant features (eigenvectors associated with large eigen values) are called eigen faces. The projection operation characterizes a face image by a weighted sum of eigen faces. Recognition is performed by comparing the weight of each eigen face between unknown and reference faces.

B. Dimensionality Reduction

We know from linear algebra theory that for a PxQ matrix, the maximum number of non-zero eigen values that the matrix can have is min(P-1,Q-1).Since the number of training images (P) is usually less than the number of pixels (M*N), the most non-zero eigen values that can be found are equal to P-1. So we can calculate Eigen values of A'*A instead of A*A'. It is clear that the dimensions of A*A' is much larger that A'*A. So the dimensionality will decrease.

C. Methodology used for PCA

In our experiment, we are using Mahalanobis distance method for similarity measures. Mahalanobis Similarity

To measure the similarity between the original data and reconstructed data we employ Mahalanobis distance instead of Euclidean distance. By introducing Mahalanobis distance, we obtain a generalized distance measure for face recognition, which can embody different weights on different components of feature vector. Mahalanobis distance has been proved as a better similarity measure than Euclidean distance, when it comes to pattern recognition problem. It takes into account the covariance between the variables and hence removes the problems related to scale and correlation that are inherent with the Euclidean Distance. It is given as:

$$d(x,y)=\sqrt{(x-y)^T C^{-1}(x-y)}$$

Where C is the covariance between the variables involved.

III. LINEAR DISCRIMINANT ANALYSIS

Linear Discriminant Analysis (LDA) is commonly used technique for data classification and dimensionality reduction. It easily handles where the within-class frequencies are unequal and their performances has been examined on randomly generated test data. This method maximizes the ratio of between-class variance to the within-class variance in any particular data set thereby guaranteeing maximal separability. The difference between LDA and PCA is that PCA does feature classification and LDA does data classification. In PCA, the shape and location of the original data sets changes when transformed to a different space whereas LDA doesn’t change the location but only tries to provide more class separability and draw a decision region between the given classes.

LDA is a supervised dimensionality reduction technique. It projects high-dimensional data onto a lower dimensional space by maximizing the separation of data points from different classes and minimizing the dispersion of data from the same class simultaneously, thus achieving maximum class discrimination in the dimensionality-reduced space.

Linear Discriminant analysis or Fisher faces method overcomes the limitations of eigenfaces method by applying the Fisher’s linear discriminant criterion. This criterion tries to maximize the ratio of the determinant of the between-class scatter matrix of the projected samples to the determinant of the within-class scatter matrix of the projected samples. Fisher discriminant group images of the same class and separates images of different classes.

As with Eigen space projection, training images are projected into a subspace. The test images are projected into the same subspace and identified using a similarity measure. Unlike the PCA method that extracts features to represent face images, the LDA method tries to find the subspace that best discriminates different face classes.

A. Main Goal of LDA

1. It perform dimensionality reduction while preserving as much of the class discriminatory information as possible.
2. It seeks to find directions along which the classes are best separated.
3. It takes into consideration the scatter within-classes but also the scatter between-classes.
4. It has capable of distinguishing image variation due to identity from variation due to other sources such as illumination and expression.

B. Methodology Used

In our experiment, we are using Cosine distance method for similarity measures.

Cosine Similarity

Cosine similarity is a measure of similarity between two vectors of an inner product space that measures the cosine of the angle between them. Cosine distance is a term often used for the complement in positive space, that is: $D_C(A,B) = 1 - S_C(A,B)$. One of the reasons for the popularity of Cosine similarity is that it is very efficient to evaluate, especially for sparse vectors, as only the non-zero dimensions need to be considered.

IV. IMPLEMENTATION OF PCA AND LDA

We have used faces from PS database for present work. MATLAB 7.1 is used to carry out this research work. First of all, the image preprocessing steps are carried out for improving performance of algorithms. Then by applying principle component analysis and linear discriminant analysis, face recognition is done. Further the performance of PCA and LDA based algorithms was evaluated with respect to face recognition rate and verification rate.

Fig (1) : Sample images from Plastic Surgery Database

Plastic Surgery Database

The Plastic Surgery database consists of 1800 full frontal face images pertaining to 900 subjects. The database contains a wide variety of cases such as rhinoplasty (nose surgery), blepharoplasty (eyelid surgery), browlift, skin peeling, and rhytidectomy (face lift). For each individual, there are two frontal face images with proper illumination and neutral expression: the first is taken before surgery and the second is taken after surgery. The database contains 519 image pairs corresponding to local surgeries and 381 cases of global surgery (e.g., skin peeling and face lift).

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Fig (1): Recognizing Pre-surgery and Post-surgery images using PCA

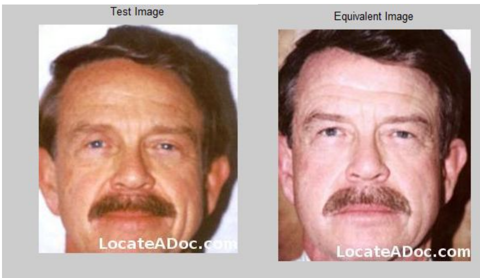


Fig (2): Recognizing Pre-surgery and Post-surgery images using LDA

The method of PCA and LDA implementation in MATLAB programming is shown as a block diagram in Fig (3).

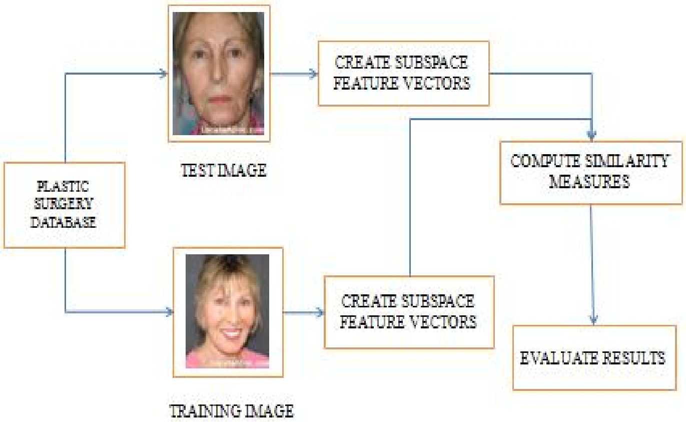


Fig (3) : Block Diagram of PCA and LDA

PROCEDURE FOR IMPLEMENTATION

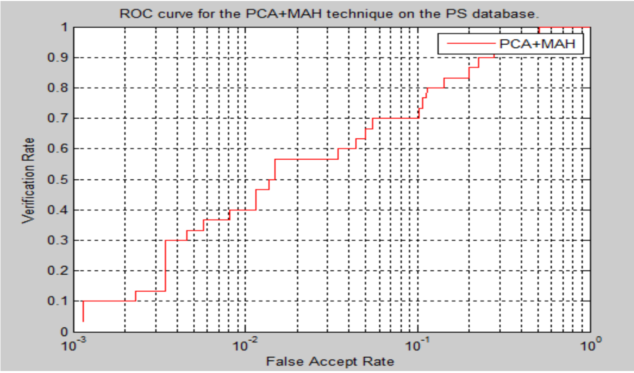
1. Load the Plastic surgery database
2. Partitioning the database into training and test data. In our case, pre-surgery image is taken for training and post-surgery image is taken for testing. .
3. Create the subspace for both training image and test image using PCA and LDA feature extraction method.
4. Compute matching score between training feature vectors and test feature vectors using Mahalanobis similarity measures for PCA and Cosine distance for LDA.
5. Evaluate the results by producing ROC and CMC curves respectively.

ROC AND CMC CURVE

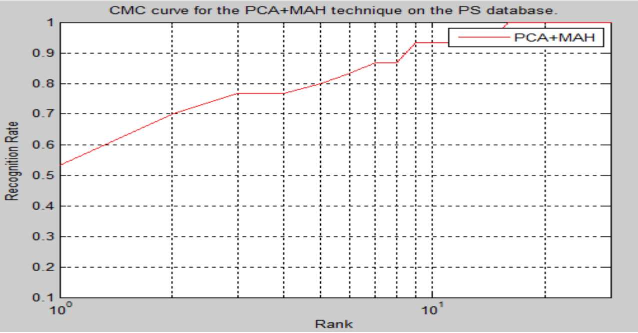
The Cumulative Match Curve (CMC) is used as a measure of 1: m identification system performance. It judges the ranking capabilities of an identification system. The Receiver Operating Characteristic curve (ROC curve) of a verification system, on the other hand, expresses the quality of a 1:1 matcher. The ROC and CMC curves has been plotted to show the performance of PCA and LDA for face recognition on Plastic Surgery database.

Fig (4) and Fig (5) shows the ROC and CMC curve of PCA when no of subjects is 30. Fig (6) and Fig (7) shows the ROC and CMC curve of LDA when no of subjects is 30.

SIMULATION RESULTS OF PCA



Fig(4) : ROC Curve for Verification Rate Vs False Accept Rate when no of subjects is 30 using PCA

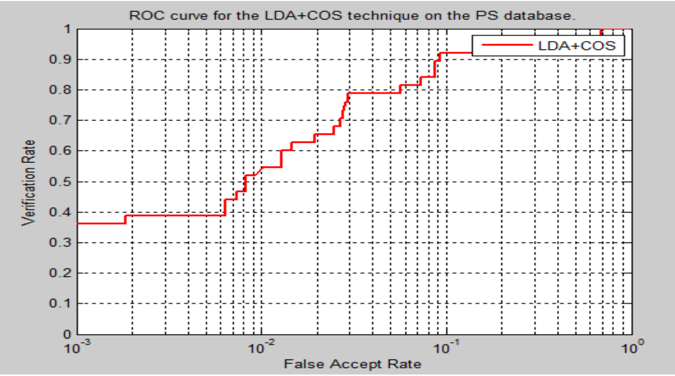


Fig(5) : CMC Curve for Recognition Rate Vs Rank when no of subjects is 30 using PCA

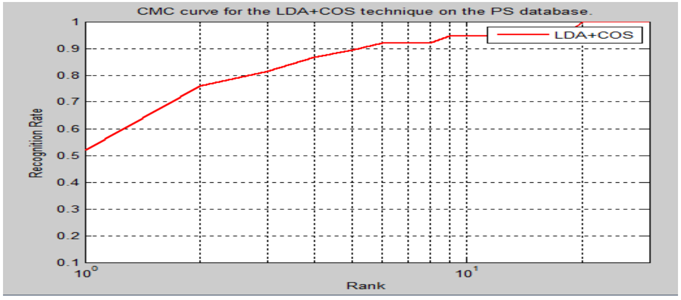
Table 1 : Analysizing the Recog.Rate Vs FAR for different no. of subjects based on PCA

NO OF SUBJECTS	RANK ONE RECOGNITION RATE IN %	ERROR RATE IN %	FALSE ACCEPT RATE IN 1%
10	80	10	70
20	75	20	55
30	53.33	16.61	40

SIMULATION RESULTS OF LDA



Fig(6) : ROC Curve for Verification Rate Vs False Accept Rate when no of subjects is 30 using LDA



Fig(7) : CMC Curve for Recognition Rate Vs Rank when no of subjects is 30 using LDA

Table 1 : Analysizing the Recog.Rate Vs FAR for different no. of subjects based on LDA

NO OF SUBJECTS	RANK ONE RECOGNITION RATE IN %	ERROR RATE IN %	FALSE ACCEPT RATE IN 1%
10	84	8	68
20	72	8.05	56
30	53	8.64	54.67

Table 3 : Performance details of PCA and LDA for different no of subjects

Algorithms	No of subjects =10	No of Subjects =20	No of subjects = 30
PCA (Mahalanobis Similarity)	80%	60%	52%
LDA (Cosine similarity)	84%	72%	53%

V. Conclusion

Facial feature and texture is drastically altered after surgery and hence the algorithms do not yield good performance. For few test cases of skin resurfacing that have relatively closer resemblance in pre and post surgery images, most of the recognition algorithms are able to perform correct classification. However, with major skin resurfacing such as surgeries to look younger, none of the algorithms are able to correctly classify the faces. Existing face recognition algorithms generally rely on local and global facial features and any variation can affect the recognition performance. The major focus in this paper has been to evaluate the performance of two important face recognition algorithms namely Principal Component Analysis (PCA) and Linear Discriminant Analysis (LDA). These algorithms are implemented in MATLAB and the performance is tested with Plastic Surgery database. The recognition rate and verification rate of these two algorithms is mainly tested in this work. The recognition percentage is quite high with LDA compared to PCA for the same no. of subjects whereas the error rate is low with LDA compared to PCA. Finally, LDA outperforms PCA for Plastic Surgery database.

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VI. REFERENCES

[1] Richa Singh, Mayank Vatsa, Himanshu S. Bhatt, Samarth Bharadwaj and Afzel Noore and Shahin S, "Plastic Surgery: A New Dimension to Face Recognition," IEEE *Trans. On Information Forensics and security,* Vol.5, No.3, Sep-2010.

[2] Richa Singh, Mayank Vatsa, "Effect of Plastic Surgery on Face Recognition: A Preliminary Study," *In Proc. Of IEEE Computer Society Conference on Computer Vision and Pattern Recognition Workshops, 2009. CVPR Workshops 2009.* 20-25 June-2009, pp.72-77.

[3] Gaurav Aggarwal, Soma Biswas, Patrick J. Flynn and Kevin W. Bowyer, "A Sparse Representation Approach to Face Matching across Plastic Surgery"

[4] Himanshu S. Bhatt, Samarth Bharadwaj, Richa Singh, Mayank Vatsa, "Recognizing Surgically Altered Face Images using Multi-objective Evolutionary Algorithm," *IEEE Trans. On Information Forensics and Security,* Vol.8, Issue.1. Jan-2013.

[5] Raghavender Jillela, Arun Ros "Recognizing Surgically Altered Face Images using Multi-objective Evolutionary Algorithm," *In Proc. of 5th IEEE International Conference on Biometrics: Theory, Applications and Systems (BTAS), (Washington DC, USA), September 2012.*

[6] K. R. Singh, Roshni S Khedgaonkar, Swati P Gawande, "A New Approach to Local Plastic Surgery Face Recognition Using Near Sets," In Proc. Of Inter. Journal of Engineering Science and Technology (IJEST) – Feb-2011.

