Performance Evaluation of Eigen faces and Fisher faces with different pre-processed Data sets

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Abstract— **The Face recognition remain a challenging area despite there are numerous face recognition algorithms came up in the last two decades. Lot of efforts went in improving the automated surveillance systems opens the door for inventing innovative face recognition algorithms. Supervised (Fisher faces) and unsupervised (Eigen Faces) face recognition algorithms are taken in to account to evaluate broadly their performances under different pre-processing data sets. Three pre-processing steps are used in considering the facial images with dark or bad lighting, low contrast. The pre-processing steps used here are contrast stretching, Homomorphic filtering and conversion of PGM image to Tagged Image File Format (TIFF), Graphics Interchange Format (GIF) and Portable Network Graphics (PNG). AT&T ORL data base is considered for evaluating the performance of Eigen faces and Fisher faces. The results show that the fisher face performs well when compared with the Eigen face for illumination changes data base. The performance evaluating curves like Cumulative Match Characteristics (CMC), Expected Performance Curve and Receiver Operating Characteristics (ROC) for Face Recognition systems are also drawn both for Eigen faces and Fisher faces for comparison.**

Index Terms— **Eigen face, Fisher face, Principle Component Analysis, Fisher Linear Discriminant, Face Recognition System.**

I. INTRODUCTION

Image enhancement techniques are very much important for face recognition and detection algorithms. Change in illumination conditions may drastically affect the face recognition rate. Before testing and training, the face data base has to be enhanced so that the affect of face recognition algorithms can be effectively seen. After all, image is considered as a bunch of pixels arranged in an array, the manipulation on the pixel may enhance the image. Because of light illumination conditions at the time of taking the face images, there are dark areas and bright areas too in the same image. All these things need to be considered before applying enhancement techniques on the face image data set for recognition rate improvement [1- 3].

In the last three decades, so many face recognition algorithms are proposed, tested and experimented. In all

these algorithms, the focus is in extracting the features of the face in the data base. Many algorithms are still working and are being used in surveillance systems [4-5]. Prominent ones are PCA and LDA.

In face recognition and detection literature, different face representation methods are used and they are global features, representing as sub spaces etc.. in face recognition basically the person is recognized by the use of large data set of face images. Two linear techniques namely PCA and LDA are prominently used for face recognition. These linear techniques create feature vector for every face in the face data base. The purpose of creating the feature vector is for dimension reduction.

Principal component analysis (PCA) method achieved the dimension reduction by projecting the original face image data onto lower dimensional subspace crossed by the best eigenvectors of the covariance matrix. Linear Discriminant Analysis (LDA) method looks for the projective axes on which the data points of two or more different classes are distant from each other, this mean LDA searches for the maximizing between class scatter, while constraining the data points of the same class to be as near to each other as possible, this mean searching for the minimizing within class scatter.

An important aspect in improving the performance of face recognition system is the enhancing of face image. The intended aim of face image enhancement is that the resulted images have better visual quality than the input one. Face image can be improved, by enhancing the brightness, contrast and resolution of image [6]. This is a part of pre-processing stage that can affect the feature extraction and finally recognition performance. For instance in, the image enhancement has been considered in face recognition technique. Song et al., calculates, prior to feature extraction stage, the illumination difference between right and left part of face. If there is a spacious amount of difference than take the mirror of average illuminated part.

The aim of this research work is to observe the effect of image pre-processing of face data base in Eigen faces and Fisher faces. The effect of combination of contrast stretching and Homomorphic filtering on the face database for improving the face recognition rate is observed. The effect of GIF, PNG and TIFF file format in improving the face recognition rate are also observed [7].

II. BACK GROUND

The Block diagrams of face recognition system and verification systems are shown in figure 1 and figure 2 respectively. Figure one shows the training stage and figure 2 show the testing stage. The pre-processing includes contrast stretching and Homomorphic filtering [8]. In the feature extraction stage, the scale vector is constructed for each and every face of the data base. If even one face in the data base is similar with the test image, the face is identified as "known", otherwise "unknown".
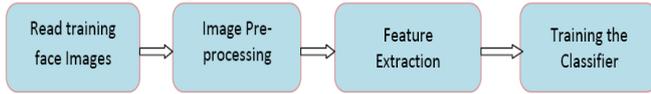

Figure 1. Block diagram of training stage of Face recognition system
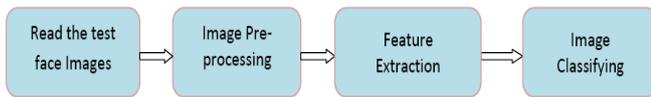

Figure 2. Block diagram of testing stage of face recognition system

A. Contrast stretching

The image brightness differences can be handled by stretching the contrasts.

Frequently, an image is scanned in such a way that the resulting brightness values do not make full use of the available dynamic range. By stretching the histogram over the available dynamic range we attempt to correct this situation. If the image is intended to go from brightness 0 to brightness 2^B-1, then one generally maps the 0% value to the value 0 and the 100% value (or *maximum*) to the value 2^B-1. The appropriate transformation is given by:

$$b[m,n] = (2^B - 1) \bullet \frac{a[m,n] - \min imum}{\max imum - \min imum}$$

This formula, however, can be somewhat sensitive to outliers and a less sensitive and more general version is given by:

$$b[m,n] = \begin{cases} 0 & a[m,n] \le p_{low}\% \\ (2^B - 1) \bullet \dfrac{a[m,n] - p_{low}\%}{p_{high}\% - p_{low}\%} & p_{low}\% < a[m,n] < p_{high}\% \\ (2^B - 1) & a[m,n] \ge p_{high}\% \end{cases}$$

In this second version one might choose the 1% and 99% values for $p_{low}\%$ and $p_{high}\%$, respectively, instead of the 0% and 100% values represented by the above equation. It is also possible to apply the contrast-stretching operation on a regional basis using the histogram from a region to determine the appropriate limits for the algorithm. Note that in eqs. and it is possible to suppress the term 2^B-1 and simply normalize the brightness range to $0 \mathrel{<=} b[m,n] \mathrel{<=} 1$. This means representing the final pixel brightness as reals instead of integers but modern computer speeds and RAM capacities make this quite feasible.

Figure 3. Original face image is on the left, and contrast stretched face image is on the right

B. Homomorphic Filtering

It simultaneously normalizes the brightness across an image and increases contrast. Here Homomorphic filtering is used to remove multiplicative noise. Illumination and reflectance are not separable, but their approximate locations in the frequency domain may be located. Since illumination and reflectance combine multiplicatively, the components are made additive by taking the logarithm of the image intensity, so that these multiplicative components of the image can be separated linearly in the frequency domain. Illumination variations can be thought of as a multiplicative noise, and can be reduced by filtering in the log domain.

To make the illumination of an image more even, the high-frequency components are increased and low-frequency components are decreased, because the high-frequency components are assumed to represent mostly the reflectance in the scene (the amount of light reflected off the object in the scene), whereas the low-frequency components are assumed to represent mostly the illumination in the scene. That is, high-pass filtering is used to suppress low frequencies and amplify high frequencies, in the log-intensity domain
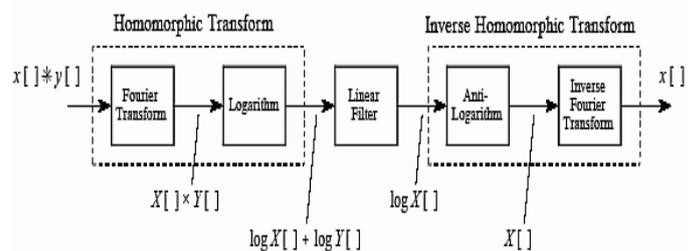

Figure 4. Block diagram of Homomorphic filtering

C. Image File Formats

The most common face image file formats, the most important for face recognition systems. Today many face databases are in different formats PGM, PNG, GIF, TIFF and many other formats, these are not the only choices of course, but they are good and reasonable choices for security purposes, for this reason we will also give a brief description to the image file formats that used in our paper.

PGM (Portable Gray Map) is a standard bitmap format consisting of a four lines header, the data stored as unsigned char type; consist of 8-bit per pixel with maximum 256 gray scale levels. The structure of a PGM images file consists of

four lines header: the first line containing the directory of the image file and identifying the file as PGM. The second line is the comment line. The third line gives information related to the number of rows and columns of the data in the file, and the fourth line identifies the maximum gray level contained in the image. The data of PGM image follows the header information and is written in text or binary format as pixel values, this mean the data is in raster order. PGM file images are generally used for displaying and printing purposes and can be opened on many packages that are commercially available like UNIX [9-12].

Pixels in PNG images may contain either a number indexing sample data in the separate table, the palette, contained in the PLTE chunk or the sample data itself, encoded as between one and four numbers. In both cases the numbers are referred to as channels and every number in the image is encoded with an identical format.

The permitted formats encode each number as an unsigned integral value using a fixed number of bits, referred to in the PNG specification as the bit depth. Notice that this is not the same as color depth, which is commonly used to refer to the total number of bits in each pixel, not each channel. The permitted bit depths are summarized in the table along with the total number of bits used for each pixel.

With indexed color images, the palette always stores trichromatic colors at a depth of 8 bits per channel (24 bits per palette entry). Additionally, an optional list of 8-bit alpha values for the palette entries may be included; if not included, or if shorter than the palette, the remaining palette entries are assumed to be opaque. The palette must not have more entries than the image bit depth allows for, but it may have fewer (for example, if an image with 8-bit pixels only uses 90 colors then it does not need palette entries for all 256 colors). The palette must contain entries for all the pixel values present in the image.

Conceptually, a GIF file describes a fixed-sized graphical area (the "logical screen") populated with zero or more "images". Many GIF files have a single image that fills the entire logical screen. Others divide the logical screen into separate sub-images. The images may also function as animation frames in an animated GIF file, but again these need not fill the entire logical screen.

GIF files start with a fixed-length header ("GIF87a" or "GIF89a") giving the version, followed by a fixed-length Logical Screen Descriptor giving the size and other characteristics of the logical screen. The screen descriptor may also specify the presence and size of a Global Color Table, which follows next if present.

An image starts with a fixed-length Image Descriptor, which may specify the presence and size of a Local Color Table (which follows next if present). The image data follows: one byte giving the bit width of the unencoded symbols (which must be at least 2 bits wide, even for bi-color images), followed by a linked list of sub-blocks containing the LZW-encoded data [13].

TIFF is a flexible, adaptable file format for handling images and data within a single file, by including the header tags (size, definition, image-data arrangement, applied image compression) defining the image's geometry.

A TIFF file, for example, can be a container holding JPEG (lossy) and PackBits (lossless) compressed images. A TIFF file also can include a vector-based clipping path (outlines, cropping, image frames). The ability to store image data in a lossless format makes a TIFF file a useful image archive, because, unlike standard JPEG files, a TIFF file using lossless compression (or none) may be edited and re-saved without losing image quality. This is not the case when using the TIFF as a container holding compressed JPEG. Other TIFF options are layers and pages [14].

TIFF offers the option of using LZW compression, a lossless data-compression technique for reducing a file's size.

III. THE PROPOSED ENHANCEMENT APPROACH

In this section, we will describe the proposed enhancement approach, we used ORL database of PGM (92×112) file format. In our work, two specific image processing functions are applied on this database which are suitable for contrast enhancement including adjust face image and the applying of histogram equalization, then the image is transformed to JPG and BMP file formats to create two databases entered to feature extraction process by using several face recognition techniques represented by PCA, LDA, this is to evaluate the performance of these techniques after the enhancement process.
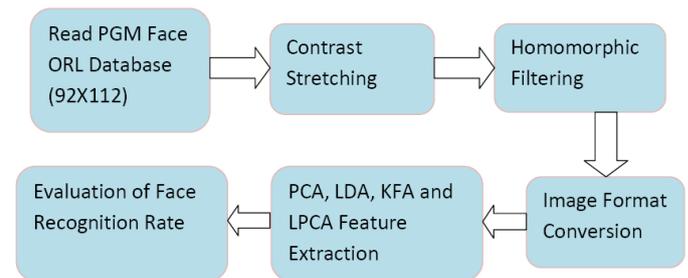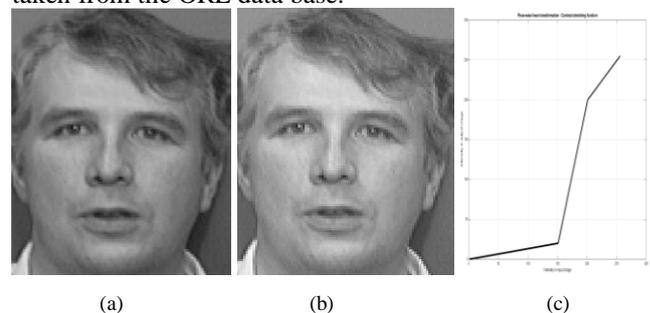

Figure 5. The proposed face image enhancement and recognition block diagram

A. Contrast Stretching

The first step here is the contrast stretching. The images in the ORL data base are unevenly distributed in illumination. Therefore by expanding the contrast, light can be increased in dark parts and light can be reduced in bright parts of the regions in the image. Figure 6 and 7 are the sample images taken from the ORL data base.
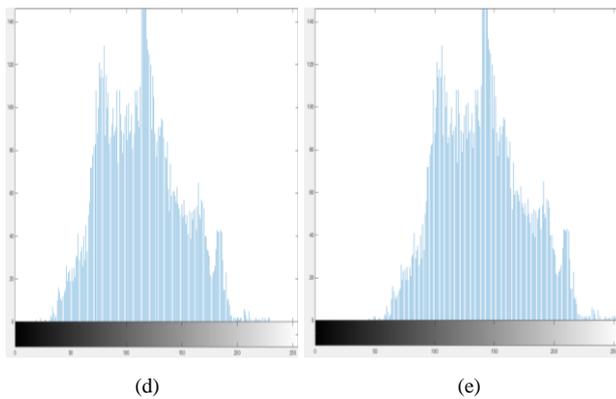

(a)   (b)   (c)

(d)　　　　(e)　　　　(f)

Fig 8: (a) is the contrast stretched image in ORL database of (a); (b) is the natural logarithm on the image; (c) is the fourier transform of (b); (d) is the Homomorphic filter of (c); (e) is the inverse fourier transform of (d) and ;(f) is the Homomorphic filtered image.

(a)　　　　(b)　　　　(c)

(d)　　　　(e)　　　　(f)

Fig 9: (a) is the contrast stretched image in ORL database of (a); (b) is the natural logarithm on the image; (c) is the fourier transform of (b); (d) is the Homomorphic filter of (c); (e) is the inverse fourier transform of (d) and ;(f) is the Homomorphic filtered image.

(d)　　　　　　　　(e)

Fig 6: (a) is the original image in ORL database (b) is the contrast stretched image (c) is the graph between the input pixel to the output pixel of contrast stretching (d) and (e) are the histograms of original image and contrast stretched images respectively.

(a)　　　　(b)　　　　(c)

(d)　　　　　　　　(e)
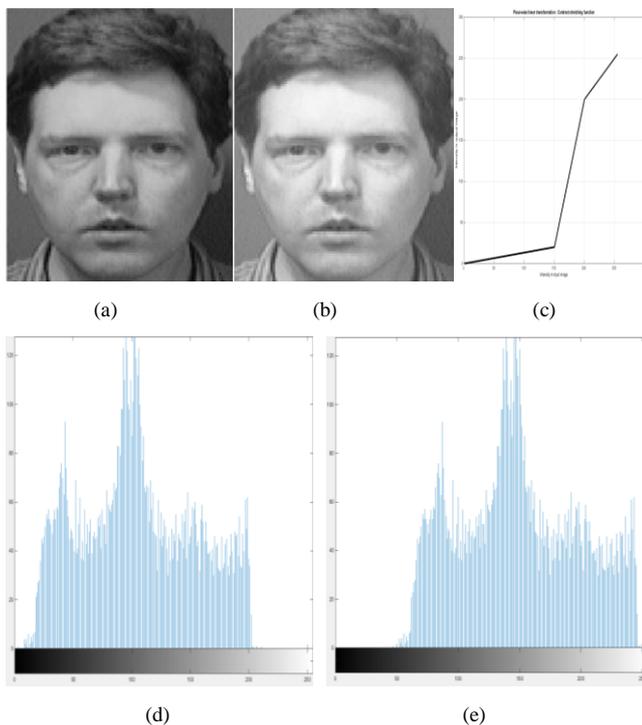
Fig 7: (a) is the original image in ORL database (b) is the contrast stretched image (c) is the graph between the input pixel to the output pixel of contrast stretching (d) and (e) are the histograms of original image and contrast stretched images respectively.

B. Homomorphic Filtering

To enhance both illumination and also the reflection, Homomorphic filtering is taken for enhancement. The results show that the image is enhanced both in reflection and illumination. The contrast stretched image is taken as input for the Homomorphic filtering.
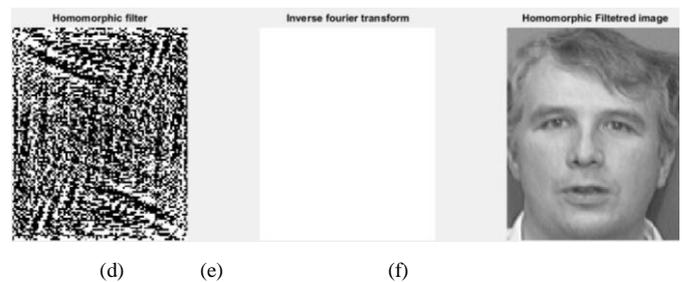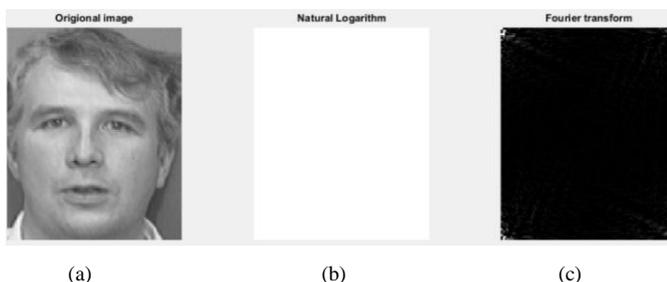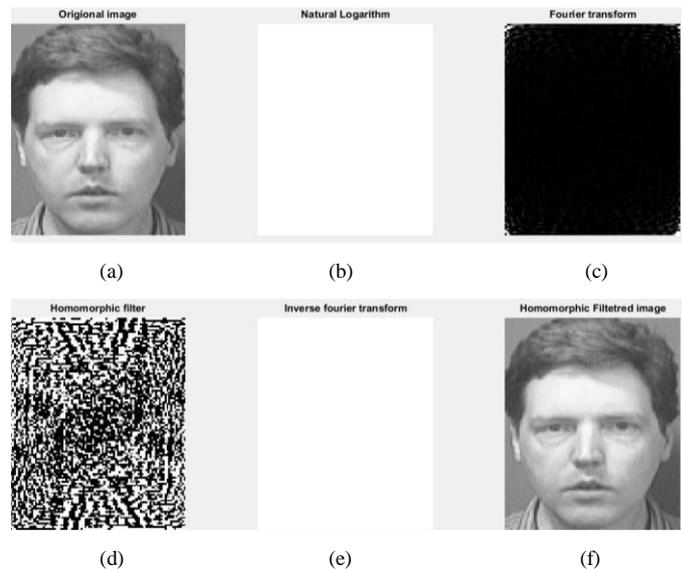

(a)　　　　(b)　　　　(c)

C. Image Conversion

GIF, PNG and TIFF are taken here because all are using lossless compression techniques. We didn't go for lossy compression techniques on purpose because here we want to retain the information in the image.
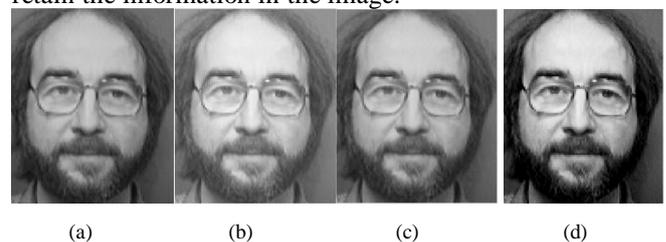

(a)　　　(b)　　　(c)　　　(d)

Figure 10. (a) is the PGM image. (c), (d) and (e) are the Pre-processed GIF, PNG and TIFF images

D. Face Recognition Feature Extraction Techniques

. The data base which we proposed and the original ORL data base [15] are examined using statistical feature extraction method by suing different face recognition techniques namely PCA and LDA. The Pretty helpful Development (PhD) face recognition toolbox [16-18] is utilized to study evaluate the proposed data base. The PhD tool contains some of the prominent face recognition techniques namely PC and LDA.

The steps for the face recognition technique is given below:

1. The images are to be loaded from the data base. Here we loaded the original ORL database and also the proposed data base of forms PNG, GIF and TIFF.
2. Divide the face data in to tow sets, namely training set and testing set. In this method the first four images in each set are considered for training purpose and the rest of the images are considered for the testing purpose.
3. Develop the training and testing feature vectors using these techniques. In this case different algorithms are used for feature extraction namely PCA and LDA. Compute the subspace using the training data from the ORL database.
4. Compute the matching scores between gallery /training/target feature vectors and test/query feature vectors. In this case we use the mahalanobis cosine similarity for computing similarity matrix.
5. Find the face recognition rate for different algorithms.

IV. EXPERIMENTS AND RESULTS

In this work first we converted the original ORL database of 400PGM image files in to PNG images, GIF images and TIFF images.

With the original ORL data base and also with the pre-processed data base, Eigen faces and fisher faces are compared. The table – I shows the comparison of face recognition rates of Eigen faces and Fisher faces with original ORL data base and different pre-processed data bases.

Database used	Eigen Faces (PCA)	Fisher Faces (LDA)
ORL PGM Database	66.07%	86.07%
Contrast Stretched Homomorphic PNG database	73.52%	87.88%
Contrast Stretched Homomorphic GIF database	71.86%	86.56%
Contrast Stretched Homomorphic TIFF database	74.89%	90.59%

TABLE: 1 COMPARISON OF EIGEN FACES AND FISHER FACES RECOGNITION RATE WITH RESPECT TO ORL DATA BASE AND PRE-PROCESSED DATA BASES.

The graph between α and error rate is the Expected Performance Curve (EPC) shown both for Eigen Faces and Fisher Faces.
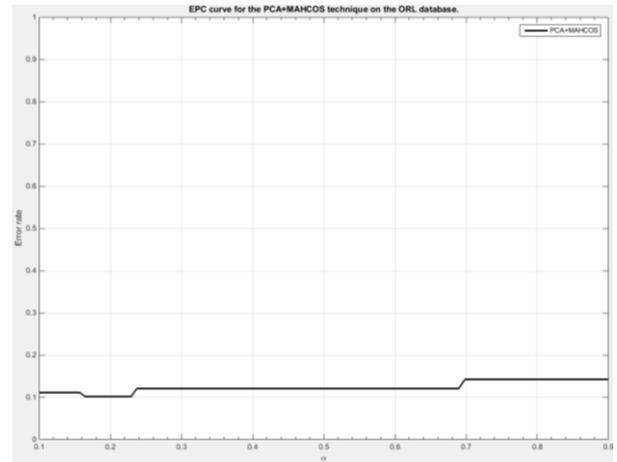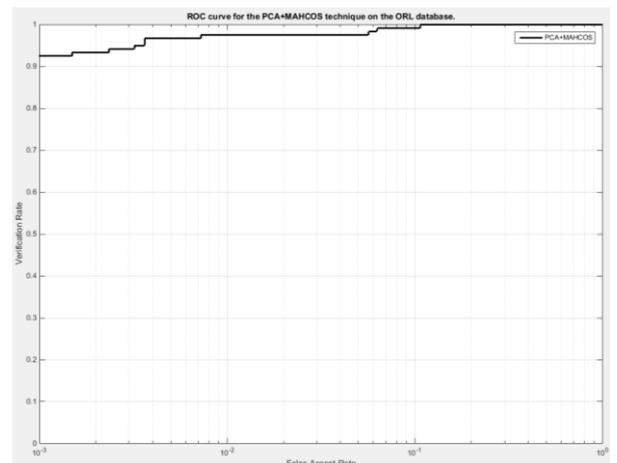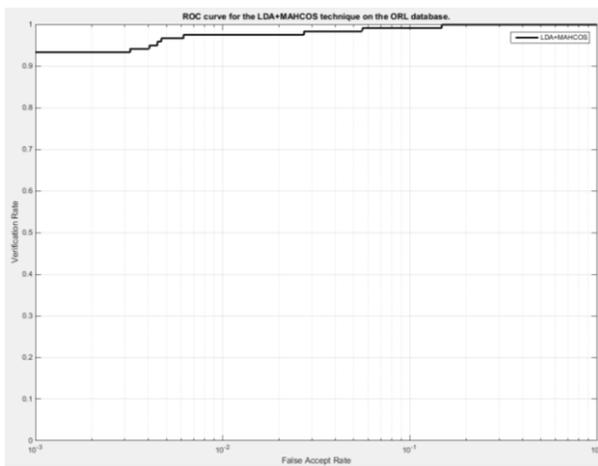

(a)
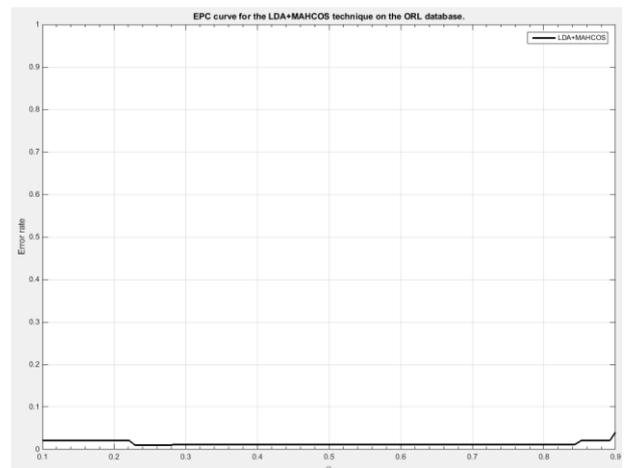
(b)

Fig 11: (a) EPC graph for Eigen faces (b) for Fisher faces

The graph between False Acceptance Rate and Verification rate is the Receiver Operating Characteristics (ROC) shown both for Eigen Faces and Fisher Faces.
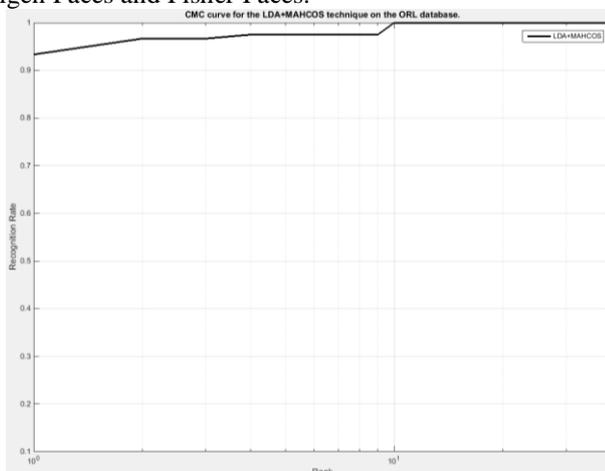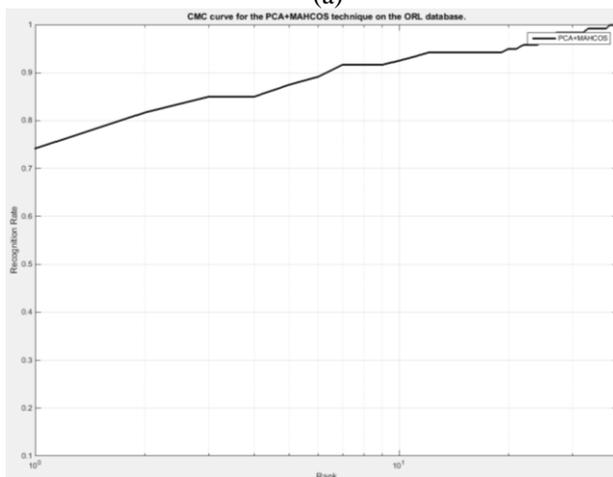

(a)

(b)

Fig 12: (a) ROC graph for Eigen faces (b) for Fisher faces

The graph between Rank and Recognition rate is the Cumulative Match Characteristics (CMC) shown both for Eigen Faces and Fisher Faces.

(a)

(b)

Fig 12: (a) CMC graph for Eigen faces (b) for Fisher faces

I. CONCLUSIONS

The aim of this work is to compare the performance of both Eigen faces and fisher faces with respect to Cumulative Match Characteristics (CMC), Expected Performance Curve (EPC) and Receiver Operating Characteristics (ROC) with different data bases.

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