Face Image Enhancement using Wavelet Denoising and Gabor Filters

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Abstract – This paper aims to enhance the recognition rate in some Gabor face recognition techniques; the enhancement is done using two filtering stages. the first stage consists of applying adapted wavelet de-noising filter on the face database, this adaptive filter is composed of two filters (Bior 1.1 and Daubachies6) which are implemented successively both are at level 10 of decomposition. The second stage consists of computing and extracting the Gabor magnitude features using Gabor filter with 5 scaling and 8 orientations. All face images are loaded from the ORL database. As a result the Adaptive filtering technique produced good enhancement when applied on face recognition techniques, since two groups are used and are compared with our work. Each group includes four face recognition techniques: the first technique is Principal Component Analysis (PCA), the second technique is the Linear Discriminate Analysis (LDA), the third technique is the Kernel Principal Component Analysis (KPCA) and the fourth technique is the Kernel Fisher Analysis (KFA). The first group is applied with non-filtered techniques and the second group is filtered with Gabor filter, both groups are compared with the same group of techniques when de-noised with the adaptive double filter.

Keywords: – Bior1.1–Daubachies6 wavelet filter, Gabor Filter, Face Recognition Rate EPC, ROC, CMC.

1. Introduction

Face acts a physiological bio-metric identifier that is commonly used in face recognition during the last three decades; face recognition has become a widely used field of research in computer vision [1]. A facial recognition system acts a computer driven application for automatically verifying a face from a digital image or a video sequence. It achieves the recognition by comparing specified facial features in the input image with a large face database. Any recognition procedure is divided into two main steps: the first step is face identification and the second one is face verification. Facial identification consists in specifying the input face image to one person of a known class, while face verification consists in accepting or rejecting the previously detected person.

The representing of face using Gabor features has cached a big interesting in image processing, computer visions and pattern recognition. The standard incentive of using Gabor filters is biological relation that the sensitive part of neurons in the essential visual bast of organisms are oriented and have properties of spatial frequencies. Gabor filters can exploit important visual characteristics like the orientation, the spatial localization, the optionally, and the spatial frequency properties [1], [2].

In this paper an adaptive face recognition system using Gabor filtering is proposed. The first portion of the adaptive recognition algorithm includes image compression using double wavelet denoising filters represented by Bior1.1 and Daubachies 6 and the second portion includes a face feature extraction process. This featuring approach processes each facial image with a filter bank including many 2D anti-symmetrical Gabor filters, at different orientations, different frequencies and standard deviations. Dependence these flooding capabilities and its big prosperity in face recognition.

This paper produces Gabor features to act the face image and offers the recognition job as related with image denoising.

2. Related Work

A few number of paper works have been adapted in the literature for Gabor features based face recognition. a Gabor wavelet based face recognition system using dynamic link architecture (DLA) scope was adapted by Lades et al. which distinguishes faces by extracting Gabor flows at each point of a rectangular toil on the face image [3], [4]. DLA and adapted Gabor wavelet-based elastic bunch graph matching (EBGM) technique was developed by Wiskott et al. to recognize and define facial images [5], In this algorithm, a graph is used to represent the face, since each node in the graph includes a set of coefficients, called toils or jets. Since, both DLA and EBGM need exhaustive amounts of computational cost. A Gabor feature based classification technique using the Fisher linear discriminate model as dimension reduction technique was extended by Liu and Wechsler [6], [7]. A model to enhance fisher using the AdaBoost method for face recognition have been produced by Shan et al. a face recognition technique using histogram of Gabor band pattern have been proposed by Zhang et al.[8]. In [9] a Gabor filter coefficient based neural network method have been proposed for face recognition, Since the researcher found the root mean square (rms) contrast is sensitive for image representation, and many experiments are applied on rms scaling, since the scaling of rms contrast gives better recognition performance.. Although Gabor filter achieved the robustness property based feature selection method but it is normally computationally expensive due to high dimensional Gabor features for this reason the feature dimensional reduction is applied by using of 15 Gabor filters, 3 filter are used for scaling and 5 filters are used for orientations.

S. Kalaimagal and M. Singh [10] found the image space , scale and orientation can produce good guide for face recognition and applied this with two steps, decomposed the image with Gabor filter and in the second step combined the local binary patterns analysis with Gabor , the proposed work give evaluated result on Feret database with different facial expressions. Singh and Singla [11], [12] developed a new method for face matching/detection based on Gabor filter and practical swarm optimization (PSO) the paradigm result was good but the complexity of this method is high. In 2012 Wavelet based image de-noising to enhance the face recognition rate is at level ten of decomposition was produced in [13]. In 2014 two pre-processing chains consist of de-noising and enhancements are suggested in [14]. In both researches [13] and [14] the work only used the wavelet denoising filter without the using of Gabor filter.

The aim of this work is to apply image de-noising using wavelet filters as attempt to take the advantage of de-noising process instead of the computational complexity that paid against the development of the Gabor filter itself. Bior1.1 and daubachies6 wavelet filter are used as double de-noising stages, then 40 Gabor filters; 5 filters used for scaling and 8 filters used for orientation are constructed. The results of the Denoising-Gabor filters are applied on some of face recognition techniques like: (PCA, LDA, KPCA and KFA) and compared with the result of the same statistical techniques when non filter and when only Gabor filter is applied on the same techniques.

3. Mathematical Model

A mathematical model is a description to the different components of the system and is used to explain the behavior of the system [15].

The mathematical modeling for the proposed system is as follows:

S= {Σ, R, δ, C}

S = Face Recognition.

Σ = set of input symbols = {image File}

R = recognition rate indicated by{EPC, ROC,CMC}

δ= the following steps:

1. Start
2. Read training set of images
3. Resize image dimensions to
4. Select training set of Dimensions, M: number of Sample images
5. Find average face, subtract from the faces in the training set, create matrix A

Where, Ψ= mean image,

M= number of images, and

Γi= image vector.

Φi = Γi – Ψ

Where, i = 1, 2, 3, …, M.

A = [Φ1, Φ2, Φ3…ΦM]

6. Calculate covariance matrix C= AA'
7. Calculate eigenvectors of the C covariance matrix.

8. Calculate eigenfaces = No. of training images –no. of classes (total number of people) of eigenvectors.
9. Create reduced eigenface space-
The selected set of eigenvectors are multiplied by the A matrix to create a reduced eigenface .
10. Calculate eigenface of image.
11. Calculate Euclidian distances between the image and the eigenfaces.
12. Find the minimum Euclidian distance.
13. Output: recognition rate with EPC, ROC, CMC curves.

4. Block Diagram of the Work

The proposed system framework can be shown in Figure (1).

4.1. De-noising Filter with Gabor Filter

Orthogonal filter banks have big interest in many applications and areas of image processing and computer vision. The property of symmetry in the filters is very essential to process the boundary distortions of end length signals effectively, and the property of orthogonality in filter banks keeps the energy of the input signal in the subbands, which prevent errors arising from quantization or the transmission will not be amplified. In addition, the result are gotten from orthogonality is high energy compaction and it is important to build and design filter banks that are both symmetric and orthogonal [16].

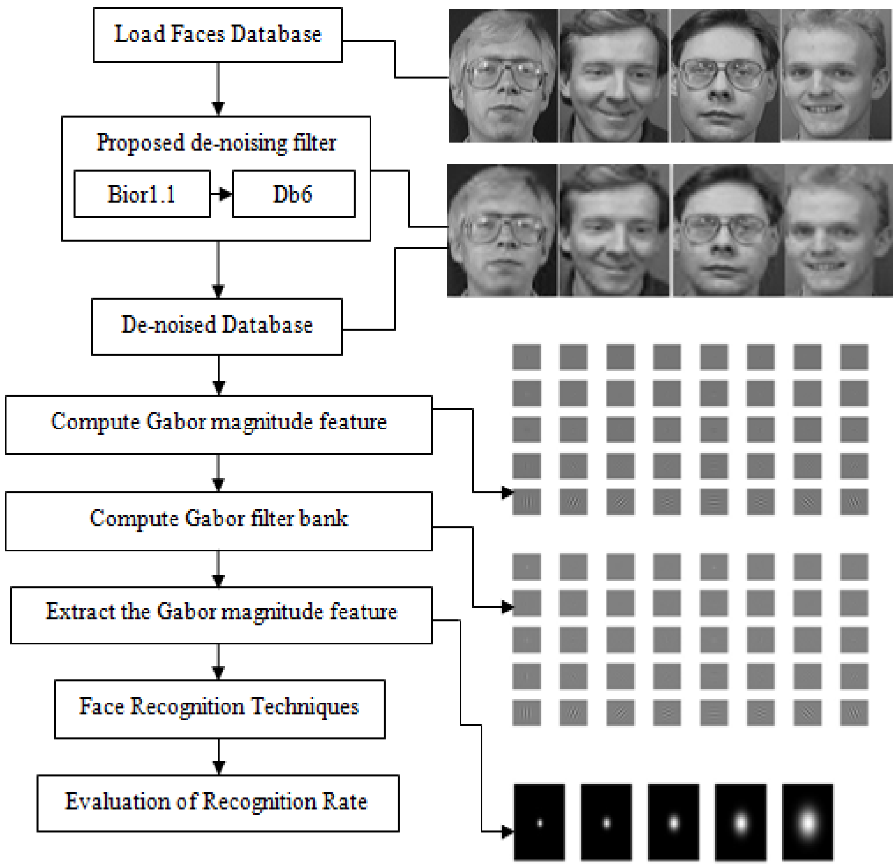

Figure 1 The adaptive system block diagram

For image denoising, biorthogonal is a well-known kind of symmetrical wavelet filter. Biorthogonal wavelet is indicated by the two scaling filters one for reconstruction and the second for decomposition. Symmetric wavelet filters are benefit to use because a symmetrical area at the image edges can be used, producing less distortion and providing higher denoising.

In this paper two filters associated with the biorthogonal (orthogonal) wavelet and Daubachies 6 (symmetric) wavelet filter are used to de-noised the face database, the main reason of using these two filters together is many of the gabor bank that resulted from the Gabor filter are not orthogonal. Biorthogonal is used to achieve the orthogonality and Daubachies filter is used to remove the redundant information by exhibiting the symmetric property.

4.2. Adaptive De-noising-Gabor Algorithm

The whole adaptation process is as follows:

Step1: Load face images database as PGM format.

Step2: Applying multi-scale decomposition of the noisy image using bior1.1 filter.

Step3: Computing the appropriate coefficients of the noisy image with ten different levels of decomposition.

Step4: Choosing only the coefficients which are higher than the threshold and shrink those which are less than the threshold to 0.

Step5: Combining the coefficients as a vector (those with the same spatial location across adjacent scales), this means the row vector constructed by finding the transposed column matrix of the wavelet coefficients.

Step6: Reversing the multi-scale decomposition to retrieve the denoised image.

Step7: Repeating the steps 1 to 6 using daubachies6 wavelet filter to re-build the image.

Step8: Converting the denoised images to JPG format.

Step 9: Compute PSNR and MSE.

Step 10: preparing and loading face images from the de-noised database.

Step 11: Partitioning data to training set and test set, ten images for each individual, 3 images in the training set and 7 images in the test images.

Step 12: Computing the feature vectors using different Gabor algorithms (GPCA, GLDA, GKPCA, and GFA).

Step 13: Compute matching scores between training feature vectors and test feature vectors, Mahalanobis cosine similarity for computing similarity matrix is used find the matching scores.

Step 14: Evaluate results by computing the face recognition rate and evaluate ROC, EPC and CMC plot results.

5. Experiments and Results

Our experiments applied on ORL database with 400 face image and the comparison result are shown as indicated in section 5.1 and 5.2 respectively.

5.1. Evaluation of the proposed filter

All face images are loaded from ORL database ORL database contains a set of face images taken between April 1992 and April 1994 in the United Kingdom, Cambridge, AT&T laboratory are used for our experiments. The reason behind the using of this database is it act as a large data set , since it consist of a ten different images for each of 40 different subjects. For some persons, the images were taken at different times, under varying lighting conditions, at different facial expressions (open or closed eyes, smiling or sad and so on) and with various facial details (glasses / no glasses). All the face images were picked over a dark homogeneous background with different positions (upright and frontal). All face images are in Portable Gray Map (PGM) format, and the original size is 92x112 pixels, with 256 grey levels per pixel, of each image. In our work all face images are de-noised using the proposed double filter, then Gabor magnitude features are extracted. This step is needed to construct the Gabor filter bank and extract the Gabor magnitude features.

Table 1. PSNR and MSE for wavelet filters at level 10 of decomposition

	PCA	LDA	KPCA	KFA
Non filter [17,18]	66.07%	86.07%	49.29%	85.71%
Gabor filter [17,18]	74.17%	93.33%	80.00%	93.33%
Adaptive Gabor result	81.67%	95.83%	81.67%	94.17%

The proposed de-noising filter is applied on ORL database after convert all face image database to JPG format, then applied the Gabor face recognition technique, our adaptive face recognition techniques are compared with the performance of 2 sets of 4 statistical face recognition techniques: PCA, LDA, KPCA and KFA the first set when non filter is used and the second set when Gabor filter is applied on these techniques both groups used original PGM ORL database. Table (1) shows a comparison result of our proposed adaptive techniques against other the two single filters. two criteria's measures include the Peak Signal to Noise ratio (PSNR) and the Mean square Error (MSE). The higher value of PSNR ratio means the better de-noising, and the smaller value of MSE means the better de-noising.

Figure 2 Sample of face image from ORL database

Table 2. Comparison in recognition rate between our de-noised face recognition techniques with non-filtered techniques and Gabor filtered techniques when 400 face images are used.

Filter Used	PSNR	MSE
Bior1.1	28.8325	85.0808
Daubachies6	30.1437	62.9094
Proposed filter	32.5562	47.5645

5.2. *Comparison Results*

In this work three curves are used to apply our comparisons are: Receiver Operating Characteristic (ROC)[18], Expected Performance Curve (EPC) [19] and Cumulatic match curve (CMC) [20].

The plots of Figure 3 show the ROC and CMC performance on the original PCA, LDA, KPCA and KFA Result on 400 pgm ORL database

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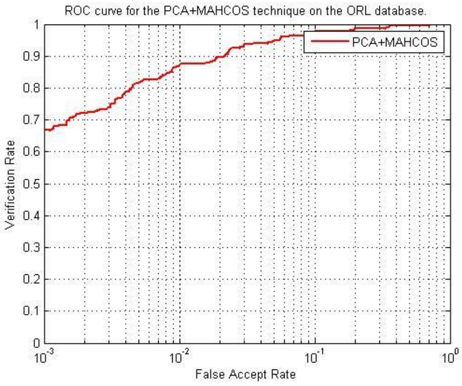

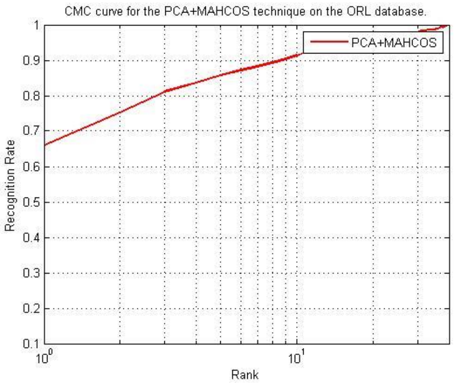

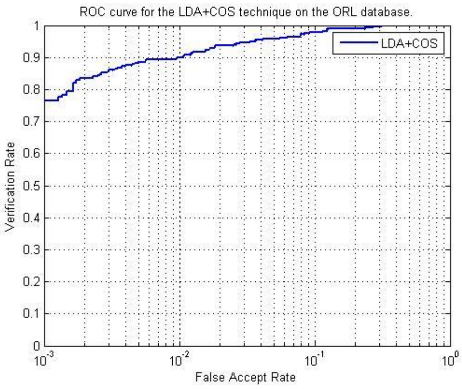

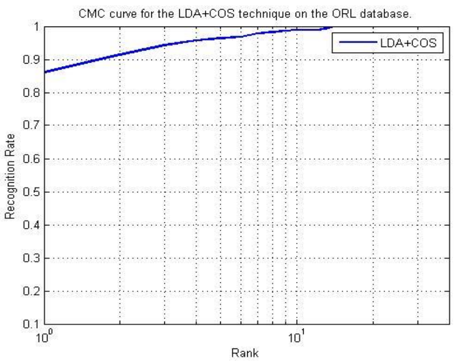

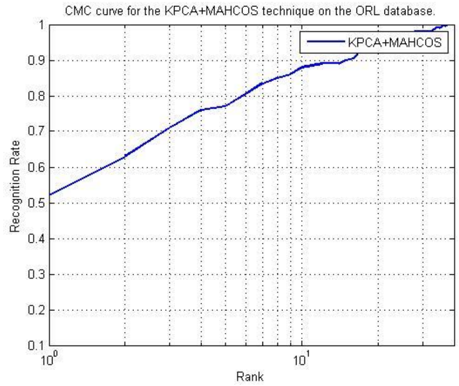

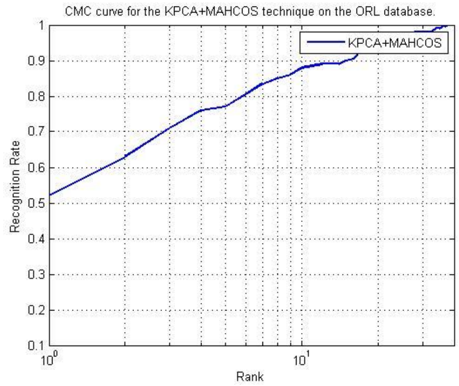

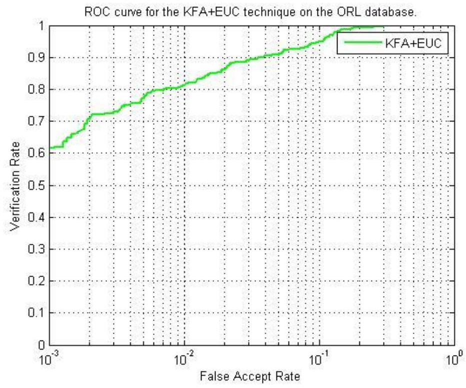

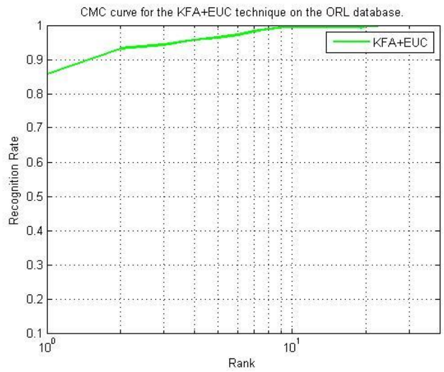

Figure 3 ROC and CMC performance on the original PCA, LDA, KPCA and KFA

The plots of Figure 4 show a comparison between ROC, EPC, and CMC performance on Gabor PCA (see left-side curves) and the adaptive Gabor PCA (see right-side curves).

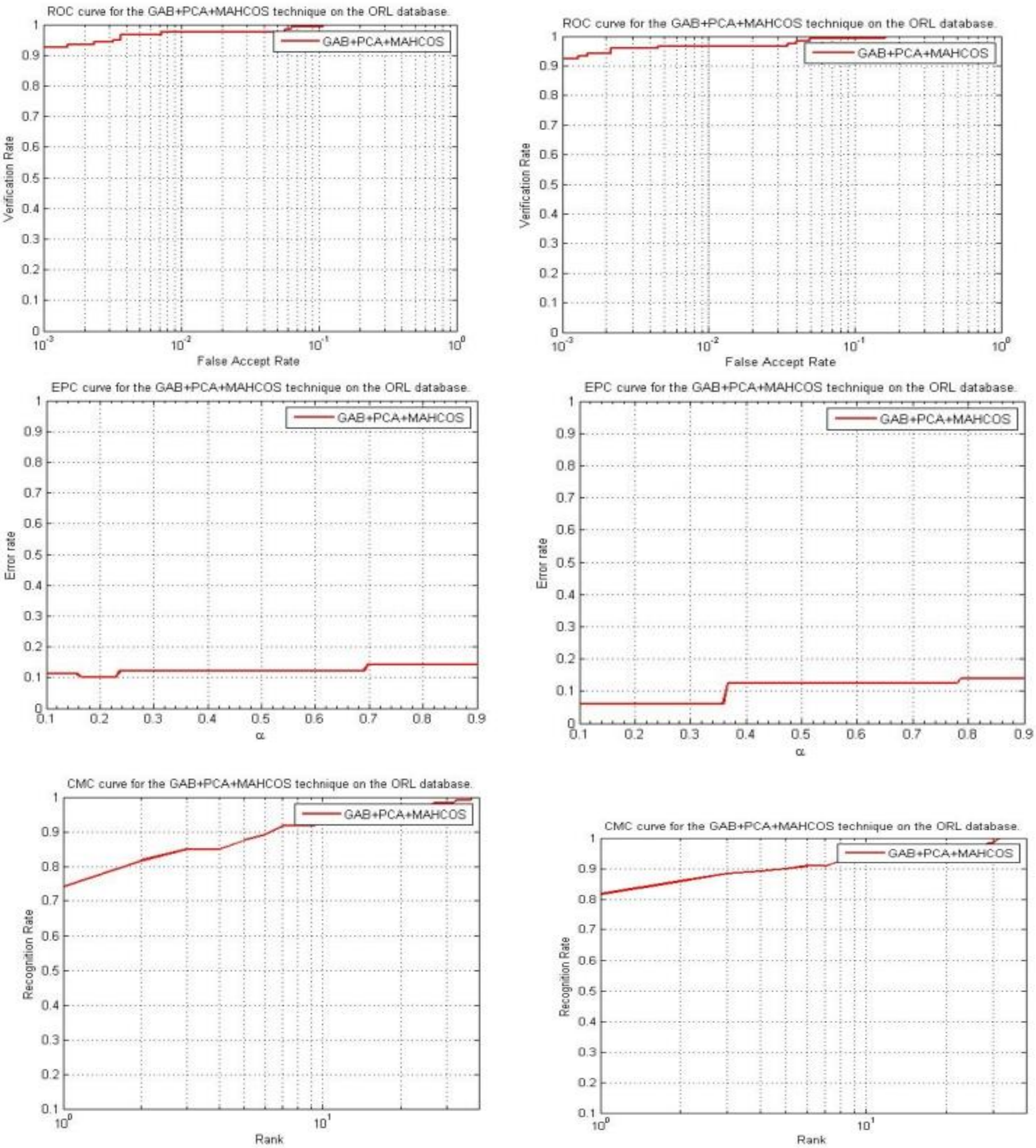

Figure 4. A comparison between ROC, EPC, and CMC performance on Gabor PCA and the adaptive Gabor PCA

The plots shown in Figure 5 represent a comparison between EPC, CMC and ROC performance on Gabor LDA (see left-side curves) and adaptive Gabor LDA (see right-side curves).

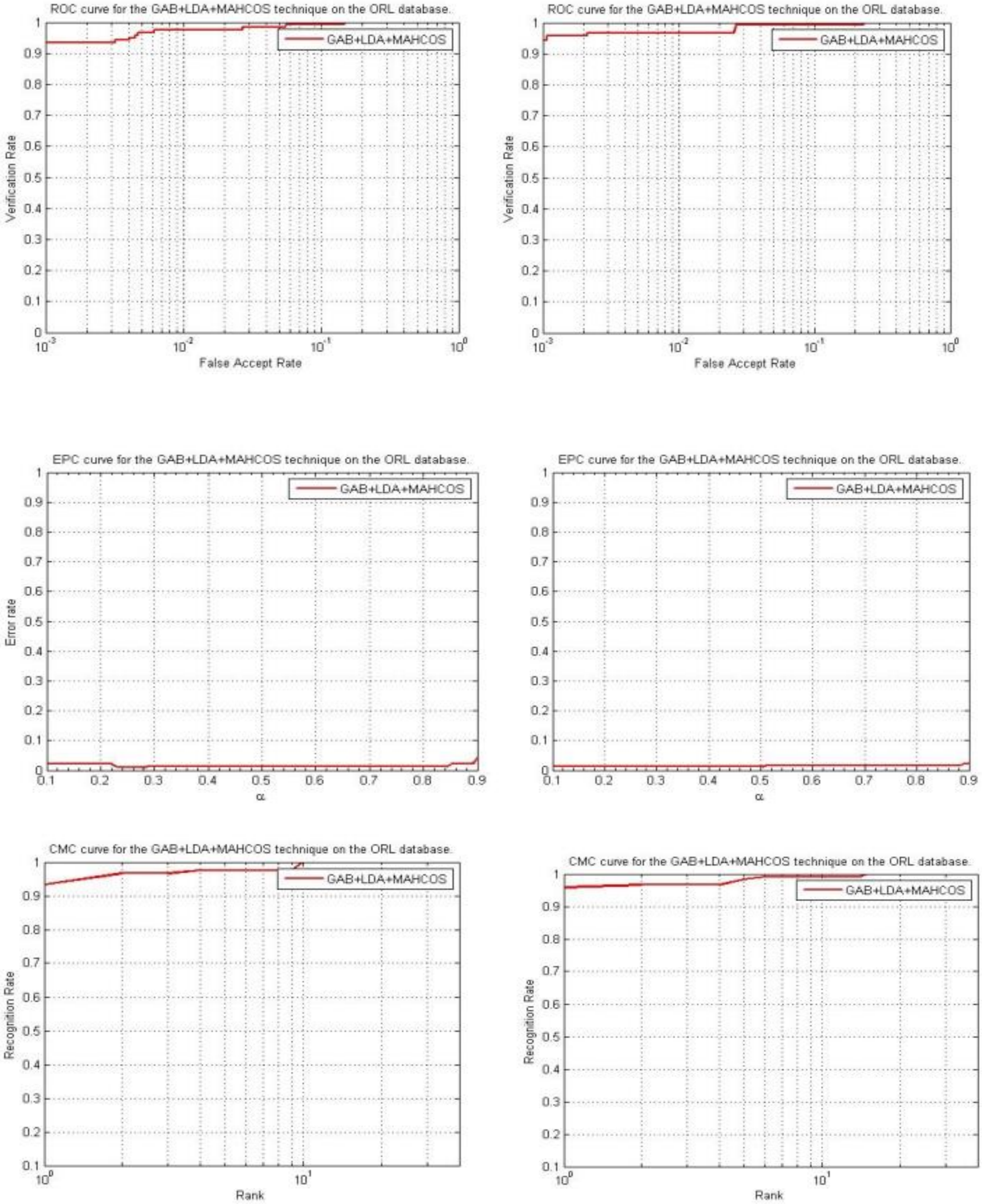

Figure 5. A comparison between EPC, CMC and ROC performance on Gabor LDA and adaptive Gabor LDA

The plots of Figure 6 show a comparison between the EPC, CMC and ROC performance on Gabor KPCA(see left -side curves) and the adaptive Gabor KPCA (see right-side curves) respectively.

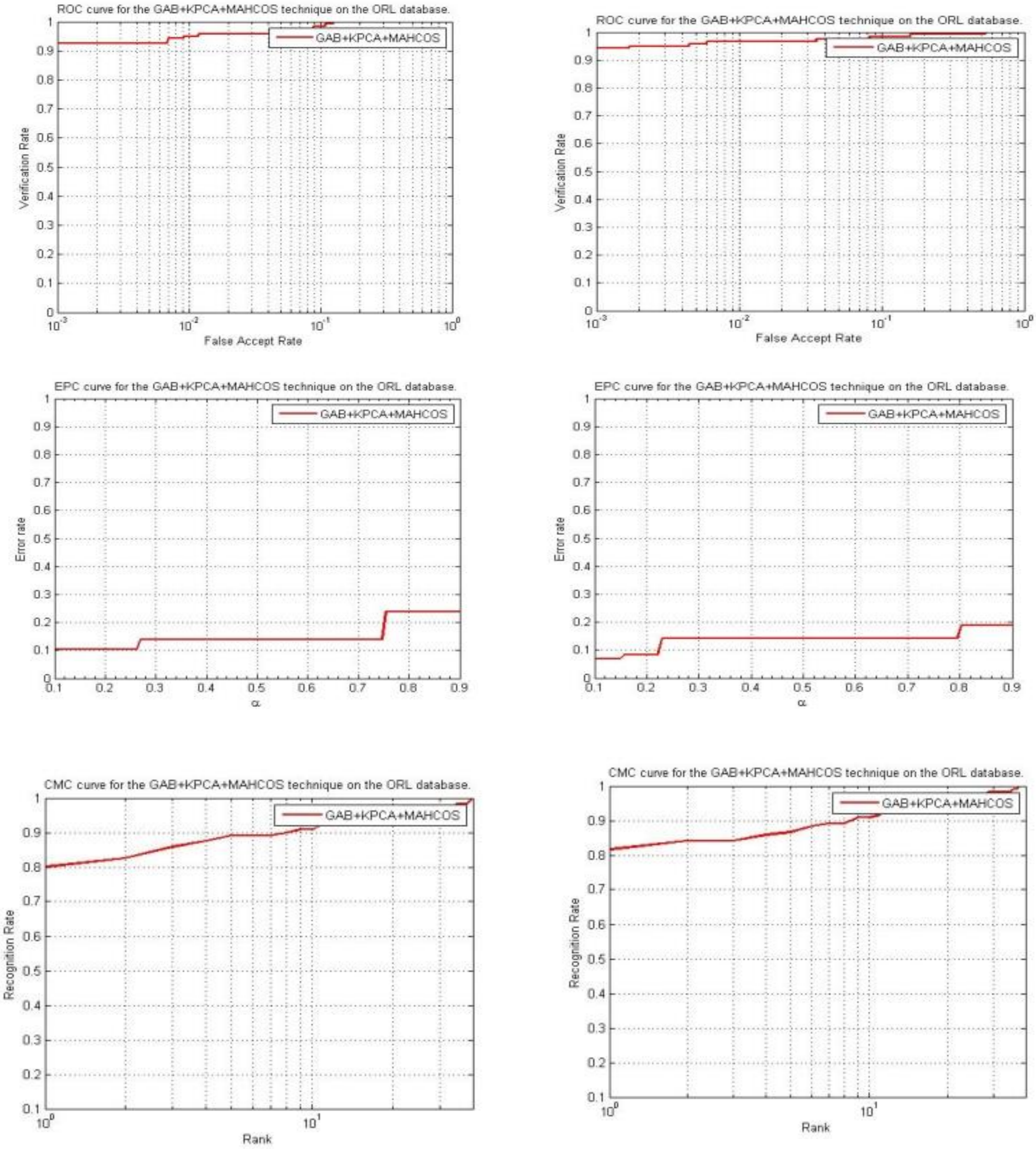

Figure 6. A comparison between the EPC, CMC and ROC performance on Gabor KPCA and the adaptive Gabor KPCA

Finally, the plots shown in Figure 7 represent a comparison between the EPC,CMC and ROC performance on Gabor KFA(see left-side curves) and adaptive Gabor KFA (see right-side curves) respectively.

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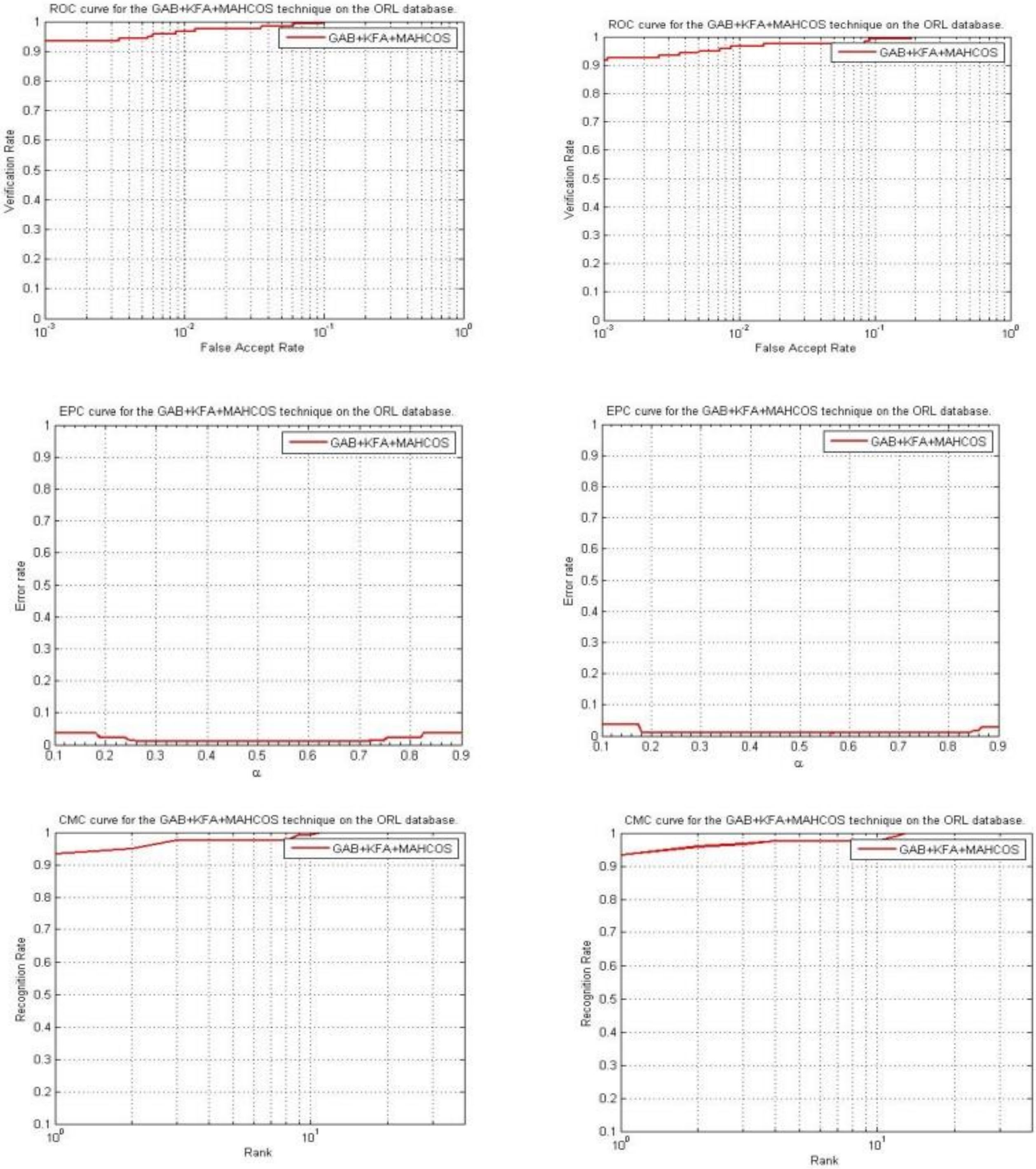

Figure 7. A comparison between the EPC, CMC and ROC performance on Gabor KFA and adaptive Gabor KFA respectively

6. Conclusion

The intended aim of face recognition systems is to get and extract face images which are very identical and matched to a specific query face image in large face databases. The retrieved images is benefit for many applications, such as in the airport where visual surveillance is applied ,in the police office where criminal face verification is needed, and many other applications related to photo management.

Our proposed filter are applied on Gabor filter and then the resulted Denoised-Gabor face image database are applied on statistical face recognition techniques, this mean two stages of dimensional reduction are applied, one by using the compression that achieved by the image de-noising process and the second by the reducing the computation complexity of the image matrix by using this face recognition techniques.

The implementation of the adaptive filter is easy since the mathematical model of the two filters is still the same but the result is good when the two filter combined to work together as one filter with two stages one is the de-noising stage and the second is the Gabor stage.

ROC, EPC, CMC are measured and compared and as indicated in section 3.2 that illustrate there are a light change in curve drawing when compared with only Gabor filter but a large different when non filter is used , as a result, our adaptive filters contributed in raising the recognition rate up to 7%,2.5%,1.5% and 1% when Gabor techniques are used as represented by GPCA, GLDA , GPCA, GKFA respectively and raising the rate up to 15.5%,9.5%,32.5 and 9.5% when non filter techniques are used represented by PCA, LDA, KPCA and KFA.

Image de-noising using Boir1.1 and Daubachies 6 wavelet filters at level 10 of decomposition is easy to implement and a little amount of work is done concerning the preprocessing for any type of face images, in addition to say that the use of wavelet denoising over JPG rather than PGM file format is also contributed in enhanced the reorganization of face images.

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