Proposed Method for Face Image Recognition Using Spectral Eigenvector Algorithms

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Abstract: *Facial recognition systems are computer-based security systems that are able to automatically detect and identify human faces. Biometric systems Though Iris Scan, Finger Print and Hand Geometry biometric system have proven to be effective, it requires cooperation from the person being scanned, the last are critical in a wide range of applications such as banking system, E-commerce, smart cards, and access control to secure system, face recognition system is one of the most reliable biometric systems, which is used for identifying persons. The proposed system describes a method for human recognition based on eigenface, correlation distance, training set of images, and a threshold which it used to classify the images and accept the detection of images that have a minimum value below the threshold. And noise removal used to enhance the performance of the original PCA algorithm in the recognition process; it gives more accurate results in recognition. This study aim is to design a face image recognition system, which is capable*

of identifying a face with high level of accuracy. Therefore, this system can be applied to a wide range of many applications.

Keywords: Biometrics, Face Recognition, Verification, Noise, Feature Extractor, Wavelet Transform, Detection Rate.

1. Introduction

In today's networked world, the need to maintain the security of information or physical property is becoming both increasingly important and increasingly difficult [1].

Now days with the network world, we heard a lot about hackers and crackers ways to steal any password or pin code, crimes of ID cards or credit cards fraud or security breaches in any important building and then reach any information or important data from any organization or company. These problems allow us to know the need of strong technology to secure our important data. This technology is called "Biometrics". Since biometric systems identify a person by biological characteristics, they are difficult to forge in addition to the face recognition there were many examples of biometrics such as signature authentication, voice recognition and hand geometry [2].

Biometric access control are automated methods of verifying or recognizing the identity of a living person on the basis of some physiological characteristics, such as fingerprints or facial features, or some aspects of the person's behavior, like his/her handwriting style or keystroke patterns. Since biometric systems identify a person by biological characteristics, they are difficult to forge [1]. Where a Face is a three-dimensional object subject to varying illumination, pose, expression is to be identified based on its two-dimensional image (or three- dimensional images obtained by laser scan) [3]. While network security and access control are it most widely discussed applications, face recognition has also proven useful in other multimedia information processing areas [1].

The denoising method based on wavelet or wavelet packet is used widely for image denoising because wavelet provides an

appropriate basis for separating noisy signal from the image signal. The motivation is that as the wavelet transform is good at energy compaction, the small coefficients are more likely due to noise and large coefficient due to important signal features. These small coefficients can be threshold without affecting the significant features of the image [4].

2. Face Image Recognition

Face recognition is one of the most relevant applications of image analysis. It's a true challenge to build an automated system which equals human ability to recognize faces. Although humans are quite good identifying known faces, we are not very skilled when we must deal with a large amount of unknown faces [2]. There is multiple reasons that make us choose Face Recognition System from all the kinds of biometric, we will summary them in these points:

1. It doesn't need any Physical interaction from the user.
2. It is very accurate and more secure.
3. We can use any cameras or image capture device [3].

Face detection and feature extraction can be achieved simultaneously, as in Figure (1). Depending on the nature of the application, for example, the sizes of the training and testing databases, clutter and variability of the background, noise, occlusion, and speed requirements, some of the subtasks can be very challenging. For example, face detection is need to initialize face tracking, and extraction of facial features is needed for recognizing human emotion, isolating the subtasks makes it easier to assess and advance the state of the art of the component techniques [5].

3. Related Works:

In [6] Xiaoguang Lu, proposed approaches to object recognition and to computer graphics are based directly on images without the use of intermediate 3D models. Most of these techniques depend on a representation of images that induces a vector space structure and, in principle, requires dense correspondence. In [7] Bayan Al-Ghamdi & Sumayyah Allaam, proposed the meaning of face recognition system, human face features that use to identify the face, face recognition types including two dimensional system (2D) and three-dimensional system(3D), explanation of three-dimensional recognition procedures : they are (detection, alignment, measurement, representation, matching and verication or identication process). In [8] Shang-Hung Line, give an introductory course of this new information processing technology and shows the readers the generic framework for the face recognition system, and the variants that are frequently encountered by the face recognizer. Several famous face recognition algorithms, such as eigenfaces and neural networks.

4. Difference between Face Detection and Recognition:

Face Detection – two-class classification Face vs. Non-face [9], research in face recognition proceeds with the assumption that the face is already segmented from the background image. However, a complete face processing system must include an additional face detection system that is able to segment or extract faces from a complex background and supply the faces to a recognition module. An intermediary stage is that of extracting features. Figure 1 shows the three stages of face recognition. In most real life scenarios, a captured image includes multiple faces. A simplified problem is, thus, to assume the presence of only one human face in the input image. This is referred to as the face localization problem. An alternative is the task of locating features, such as eyes, nose, ears and mouth, and is referred to as facial feature detection.

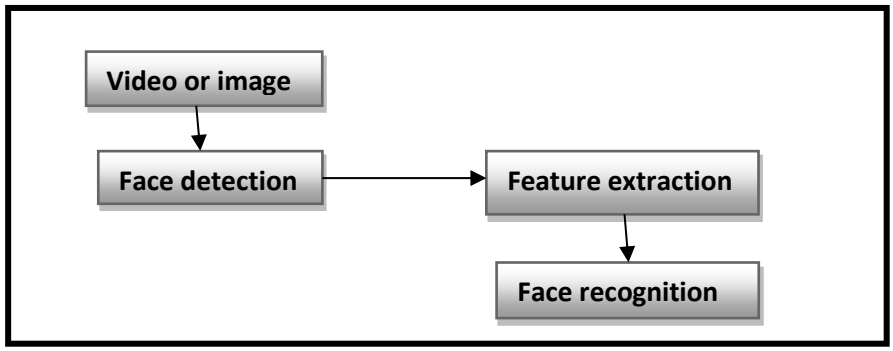

Figure 1: The three stages of a face processing system.

A measure of the effectiveness of a face detection system is the detection rate. The detection rate is calculated as:

$$\textbf{Detection rate} = \frac{\textbf{Number of faces correctly detected}}{\textbf{Total number of faces in the image as determined by a human}}$$

A detection stage can commit two kinds of errors: false positives and false negatives [9, 10].

Face Recognition – multi-class classification one person vs. all the others means many face recognition methods extend the framework of face detection approaches to learn characteristics that differentiate one identity from another. [11] Face recognition is applied either for the task of identification or verification. Identification is to match a given face image with a stored collection of identities and return an identity. Verification is to check the identity alleged by the given face image using a stored collection of images for this identity. To the recognition of faces, it is necessary to extract facial characteristics or features. Feature extraction is the task of reducing the high dimensional training data to a set of features to investigate properties (morphological, geometric etc.) of the data [12, 13].

5. Face Recognition Tasks :

The two main tasks performed by any automatic human recognition system are verification/authentication and identification. As discussed below:

1) Verification

Verification or authentication is the simplest task for a facial recognition system. An individual with a pre-existing relationship with an institution (and therefore already enrolled in the reference database or gallery) presents his or her biometric characteristics (face or probe image) to the system, claiming to be in the reference database or gallery (i.e. claiming to be a legitimate identity). The system must then attempt to match the probe image with the particular, claimed template in the reference database. This is a one-to-one matching task since the system does not need to check every record in the database but only that which corresponds to the claimed identity [14].

2) Identification

The algorithm of face recognition can be divided into the following functional modules: a face image detector finds the locations of human faces from a normal picture against simple or complex background, and a face recognizer determines who this person is. Both the face detector and the face recognizer follow the same framework; they both have a feature extractor that transforms the pixels of the facial image into a useful vector representation, and a pattern recognizer that searches the database to find the best match to the incoming face image. The difference between the two is that: in the face detection scenario, the pattern recognizer categorizes the incoming feature vector to one of the two image classes: “face” images and “non-face images. In the face recognition scenario, on the other hand, the recognizer classifies the feature vector (assuming it is from a “face” image) as “Smith’s face”, “Jane’s face”, or some other person’s face that is already registered in the database [1].

6. Eigenvector Algorithms:

Eigenvector or the Principle Component Analysis (PCA) or Karhunen-Loeve Transform is linear projection method to reduce the number of parameters, transfer a set of correlated variables into a new set of uncorrelated variables, and map the data into a space of lower dimensionality, form of unsupervised learning. [15]:

Suppose x1, x2, ..., xM are N x 1 vectors

- ✓ **Step1:** $\beta = \frac{1}{M}\sum_{i=1}^{M} Xi$
- ✓ **Step 2: Subtract the mean** $\Phi i = Xi - \beta$
- ✓ **Step 3: Form the Matrix A=[Φ1Φ2….ΦM] (N* M matrix),**

  Then $C=\frac{1}{M}\sum_{n=1}^{M} \Phi n \Phi n^{T} = AA^{T}$
- ✓ **Step 4: Compute the Eigenvalues of C: λ1 > λ2 > …. λN**
- ✓ **Step 5: Compute the Eigenvectors of C: u1, u2 …. un**
- ✓ **Step 6: (Dimensionality Reduction Step) keep only the terms corresponding to the K largest eigenvalues:**

  $\acute{o}-\beta = \sum_{i=1}^{k} b_i u_i$ **where k << N**

The representation of $\acute{o}-\beta$ into the basis **u1, u2, … , uK** is thus $\begin{cases} b_1 \\ b_2 \\ .. \\ b_K \end{cases}$ **Linear transformation implied by PCA:-** The linear transformation $R^N \rightarrow R^K$ that performs the dimensionality reduction is :

$$\begin{cases} b_1 \\ b_2 \\ \cdots \\ b_K \end{cases} = \begin{cases} {u_1}^T \\ {u_2}^T \\ {u_k}^T \end{cases}$$

Figure (2) illustrate the block diagram of the Eigenvector algorithm is [16]

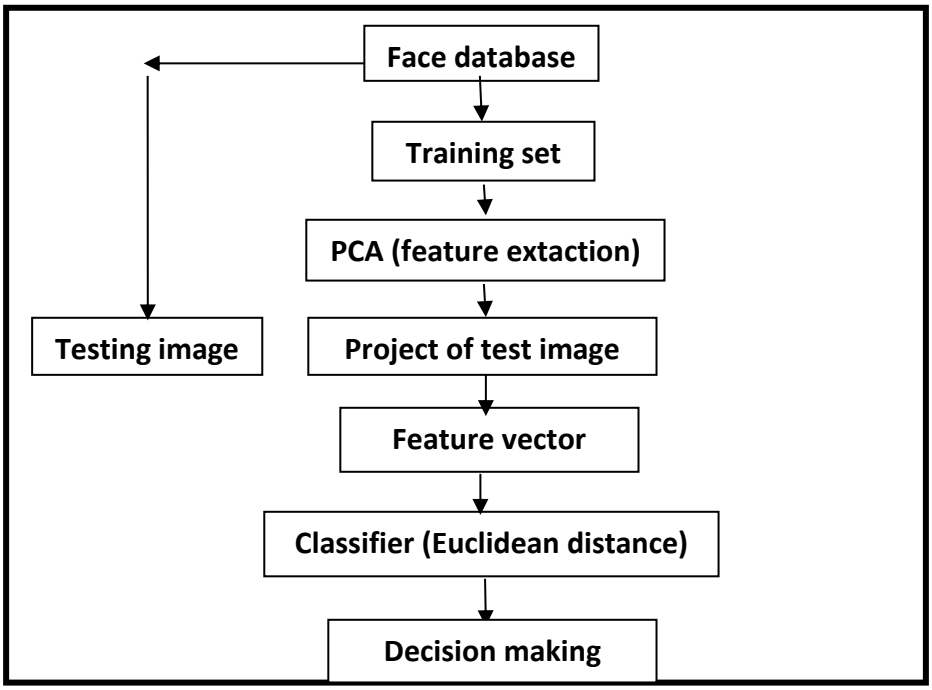

Figure 2: the Block Diagram of eigenvector algorithm

7. Noise Removal Filters methods:

Discrete Wavelet Packet Transform (DWT) which transform a discrete time signal to a discrete wavelet representation. It converts an input series x0, x1, ..xm, into one high-pass wavelet coefficient series and one low-pass wavelet coefficient series (of length n/2 each) given by:

$$\boldsymbol{H_i = \sum_{m=0}^{k-1} X_{2i-m} \cdot S_m(Z)} \quad (1)$$

$$L_i = \sum_{m=0}^{k-1} X_{2i-m} \cdot t_m(Z) \quad (2)$$

Where, sm(Z) and tm(Z) are called wavelet filters, K is the length of the filter, and i=0, ..., [n/2]-1.

Wavelet filters have been designed for a wide range of applications and many different sets of filters have been proposed for different applications. Wavelets are functions defined over a finite interval. In practice, such transformation will be applied recursively on the low-pass series until the desired number of iterations is reached.[17]

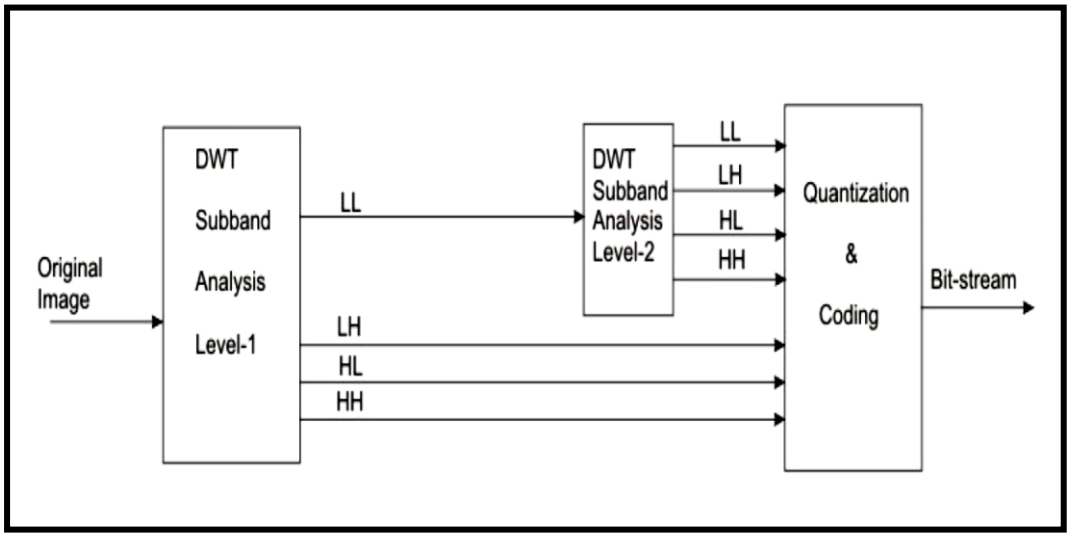

Figure 3: Two – level DWT

8. Components of the Proposed System:

The system can be explained by describing these components: Best Eigenvectors of the obtaining eigenvectors for a given dataset. Filter image by wavelet packet transform (imfilter), transform the filter image to black and white area, calculate correlation distance and pick a suitable threshold, figure (4) describes the block diagram of the proposed system.

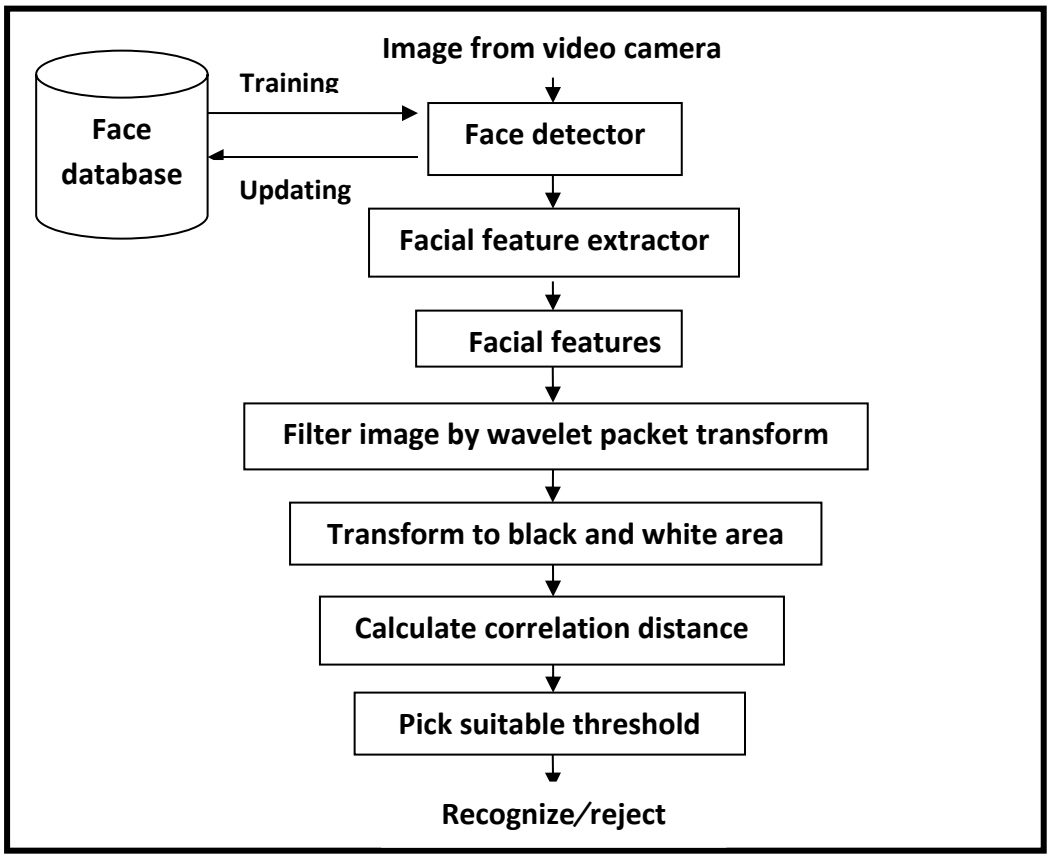

Figure 4: The Block diagram of the proposed system

9. The proposed face image recognition system:

Face recognition is one of the most difficult problems in the research area of image recognition. The following steps explain the proposed PCA recognition algorithm:

- **Step 1:** Input an unknown query image with any size can be represented as a linear combination of the best Eigenvectors of the obtaining eigenvectors for a given dataset.
- **Step 2:** Pre-Process the face image through Resize the image to be equal with the size of the sample images in the gallery.

- **Step 3:** Filter the image with wavelet packet transform noise removal filter (imfilter) as illustrated in figure (3).
- **Step 4:** The filtered face image will transformed to black and white areas by using face masking method.
- **Step 5:** Let A and B be two spectral eigenvector feature vectors where, Î ai ЄA, bi ЄB, i=1,…,n. a correlation distance is defined as[9]:

R=1-r, (3)

Where, r is the linear correlation coefficient which is given by the formula [9]:

$$r(A,B)= \frac{\sum_{I=1}(ai-a)(bi-b)}{\sqrt{\sum_{i=1}(ai-a)^2}\ \sqrt{\sum_{i=1}(bi-b)^2}} \quad (4)$$

Where, a is the mean of the vector A, and b is the mean of the vector B. The correlation distance determines the genuine or forged query sample. It is easy to verify the input pattern by a predefined threshold value T. If the value R is smaller than threshold T, then the owner of query sample is claimed to be individual A. Otherwise, the query sample is classified as a forged pattern.

- **Step 6:** In any biometric image recognition system, it is essential to pick a suitable threshold (T), for good performers results. To this end set the initial threshold value to (95%) the (5%) will be the false tolerance of the comparison, then calculate the comparison stage value with the value of the threshold if the value R is smaller than threshold T, then the owner of query sample is claimed to be individual X, otherwise the query sample is classified as a forged pattern then apply noise removal filter to the eigenface and repeat the recognition stage. The flowchart of the proposed system is shown in figure (5):

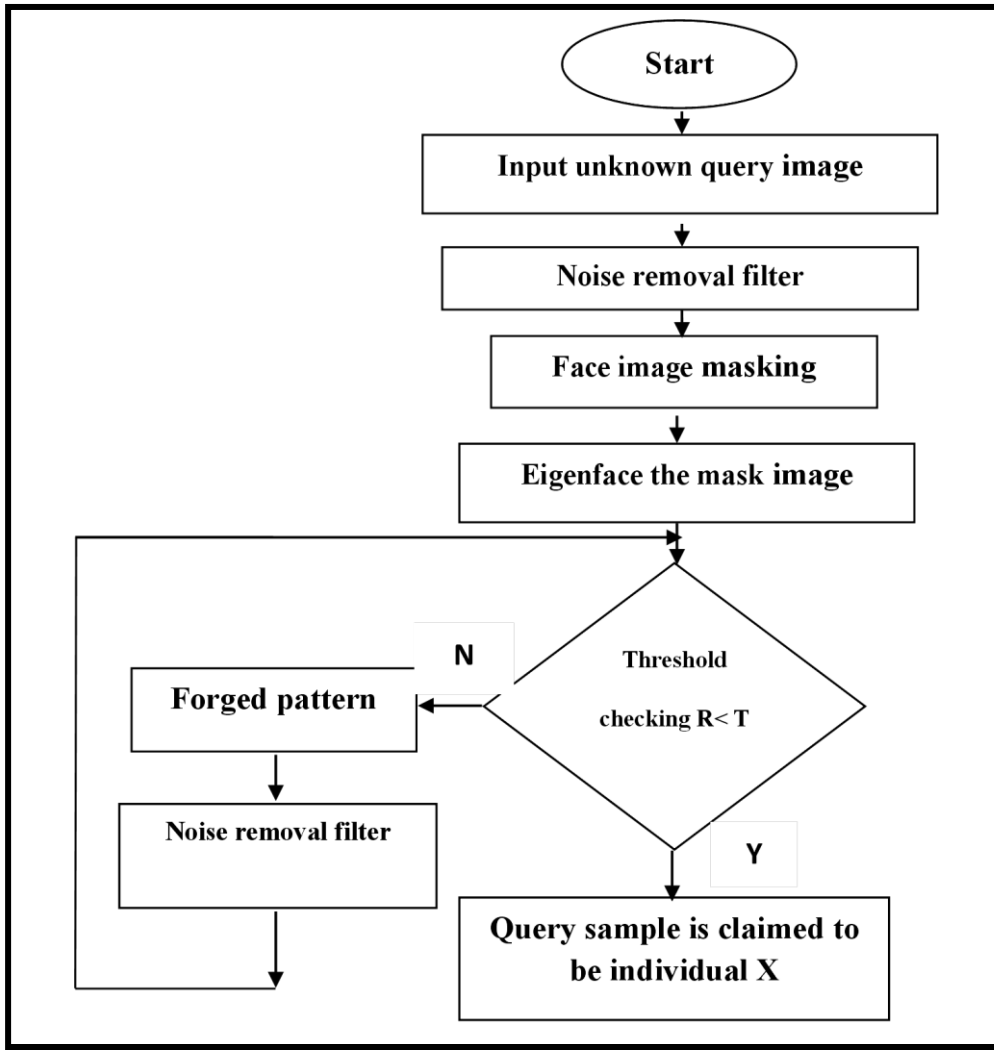

Figure 5: Flowchart of the proposed system

10.The Result:-

The proposal has been implemented on the following platform: Windows 7 Ultimate Service and 32-bit OS, 5GB RAM, and CPU with 3.00GHz; and by using Visual Basic 6.0 programming language. The results of the proposed spectral eigenvector algorithms which the query image passing through

stages noise removal and masking process before transforming to eigenvector, figure (6) illustrates these two preprocesses (noise removal and masking process):

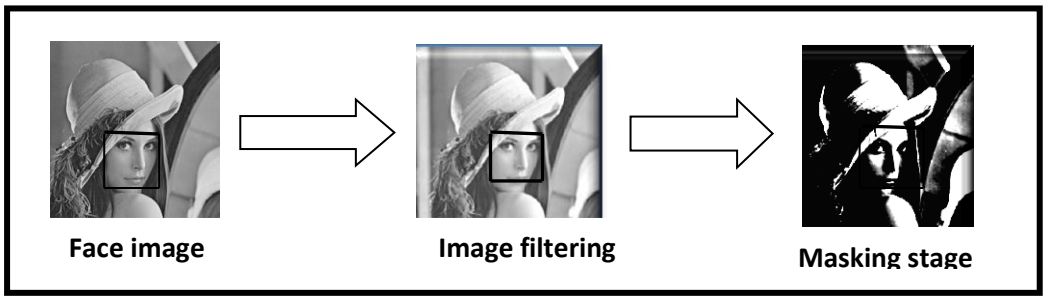

Figure 6: Noise removal and masking stages

A 40 face images are collected for 8 individuals, originally, the collected samples of the face image which are 512×512 pixels 8-bit grayscale and 2-bit grayscale image with 75dpi resolution in BMP format. The suggested algorithm to recognition face based on taking an unknown face and input it and then the spectrum eigenface is applied, the results normalized feature vector is labeled manually by convert the result feature vector to an element between [0, 1]. A threshold value T is set to 0.5 and stored in the database for the recognition phase and the proposed system will report back the determined identity then the proposed system needs to confirm or reject the claimed identity of the input face. The experiments are conducted for the identification mode for the training set of face image and the general illustration of the systems is shown in Figure (7)

Figure 7: Face representations found by Spectral Eigenvector Algorithms

Figure (8) summarizes these results of statistical estimators and comparison result in using PCA algorithms in Lennan face image which are 512×512 pixels 8-bit grayscale image with 75dpi resolution in BMP format, similarity test result such as performance of PCA algorithm in different face images are shown in table (1) .

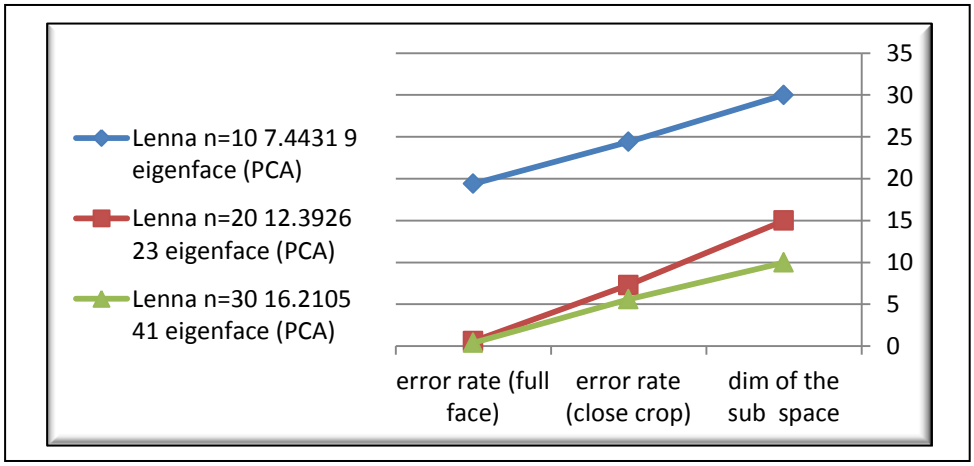

Figure 8: Result of the statistical estimators & comparison result in using PCA algorithms

Table (1): describes the comparison between performance of PCA algorithm in different image type

Face image name	type	Length	File size	Performance of PCA algorithms
Lennan	8-bit gray scale	512×512	23KB	Very good
Fr12	8-bit gray scale	512×512	7KB	complex
C23	2-bit gray scale	256×256	10KB	good
Dis13	2-bit gray scale	256×256	13KB	complex

11.Conclusions:

1. Facial makeup is less influential than other facial variations unless it is a theatrical cosmetic. Usually the face recognition system requires a certain amount of user's cooperation on this problem; that is, if we are an enrolled member in the database, it is better to not wear a rubber mask when we requesting for admission. Figure (9) is an example of how facial makeup affects the performance of the face detection.

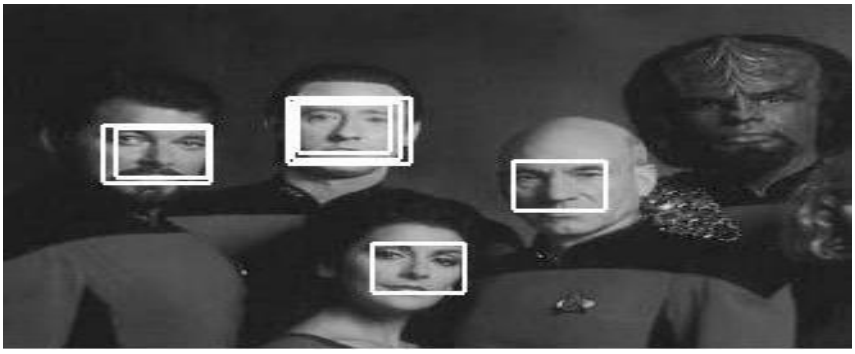

Figure 9: facial makeup affects the performance of the face detection.

2. PCA is one of dimensionality reduction technique, which is used to find a feasible subset of features that are adequate to describe the actual dataset. It iteratively identifies and removes the irrelevant information and produces the feasible subset of features.
3. This paper describes a method of fusion face for human recognition based on a new feature vectors identified as spectrum Eigenface. The output of a recognition phase in the proposed system is a list of sorted reference images in descending order by similarity with the testing image. That means, the reference image on the top of the list has the highest similarity (lowest distance) with the testing image.

4. The biometrics methods present an appropriate measure to oppose against spoof attacks, as it is hard to counterfeit several modalities at the same time, to circumvent a system.
5. The correlation distance is used to calculate the threshold value, and find the correct recognition of each individual. The thresholds value is important to prevent the imposter from being recognized.
6. Noise Removal in the spectral eignvector algorithm enhance the performance of the original algorithm in the recognition process, it gives more accurate results in recognition especially when removing noise from eigenface after the recognition process failed.

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طريقة مقترحة لتمييز صورة الوجه بأستعمال خوارزمية المتجهات الطيفية

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المستخلص

أنظمة التعرف على الوجه وانظمة الامن المعتمدة على الحاسوب هي الانظمة القادرة على تحديد والكشف عن الوجوه البشرية تلقائيا.

نظم التحقق من الهوية من خلال المسح الضوئي لقزحية العين و اخذ بصمات الاصابع ونظام التحقق من الهوية هندسيا ، ثبت بانها فعالة لكنها تتطلب التعاون من شخص يقوم بمسحها ضوئيا. وتم استخدام نظم التحقق من الهوية في مجموعة واسعة من التطبيقات مثل النظام المصرفي، التجارة الإلكترونية، والبطاقات الذكية، والتحكم في الوصول لتأمين النظام ونظام التعرف على الوجه هو واحد من اكثر نظم التحقق من الهوية موثوقية والذي يستخدم للتعرف على الأشخاص. والنظام المقترح قد استخدم طريقة تدعى محددات الوجه وبعد الارتباط مع مجموعة من الصور المعدة للتدريب بحيث يمكننا تصنيف الصور بالاعتماد على تغيير قيمة العتبة (threshold) داخل نطاق معين واستعراض الصور التي لها قيمة قليلة تحت قيمة العتبة بحيث نحصل على نتائج أكثر دقة في التعرف على الوجوه خصوصا عند إزالة الضوضاء من محددات الوجه. الهدف من هذا البحث هو دراسة لتصميم مقترح نظام التعرف على صورة الوجه، والتي لها القدرة على تحديد وكشف الوجوه مع مستوى عال من الدقة وبالتالي فإن هذا النظام يمكن استخدامه في مجموعة واسعة من التطبيقات.

الكلمات الرئيسية: القياسات الحيوية، التعرف على الوجه، التحقق، الضوضاء، استخراج ميزة، تحويل المويجات، معدل الاكتشاف.