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Security System by Face Recognition

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ABSTRACT

Background: *Authentication is one of the major challenges of the information systems era. From Among other things, recognizing the human face is one of the known techniques that can be user authentication.* ***Aim:*** *The main purpose of this paper is to study the application of the facial recognition algorithms as a security system for the examination office at Omar Al-Mukhtar University (OMU) for the first time in Libyan universities. It can detect intruders into restricted or highly secure areas, and help reduce human errors.* ***Methods:*** *This system consists of two parts: the hardware part and the software part. The device part consists of a camera, while the software part consists of the face detection and facial recognition algorithms program. The face was detect using the Viola Jones method and face recognition is performed by Use of independent component analysis (ICA). When a person enters the area in question, his photos are taken by the camera and sent to the program for analysis and comparison with an existing database of trusted people.* ***Result:*** *In this study, we used a database of people responsible for the examination office at the College of Science, the sample consisted of 100 images. The ICA algorithm was applied to recognize faces, and it achieved a result of 86.7%, which is considered a good result, as it was compared to applying the PCA algorithm on the same sample, where the result was 76.7%.* ***Conclusion:*** *Independent Component Analysis (ICA) is better than Principal Component Analysis (PCA) in some cases, but requires at least a few seconds as is training time. The face recognition-based presence system achieves the expected goal, but the accuracy of the face recognition still needs improvement.*

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INTRODUCTION

Safety is a major concern in our daily life. Access control is one of the most important areas of a security system, which controls access to a building or area such as home and office. The traditional access control security system is not reliable because it can be counterfeited and stolen. For example, the password could be exposed to an unauthorized user and the theft could show the identity card. In any case, traditional security methods such as keys and identity cards can be displaced. Therefore, the access control security system must be updated to improve security. A more reliable security system must be developed to avoid further losses. Biotechnology can be applied to a security system to control access because it provides a higher level of security. Biometrics is the safest and most practical authentication tool because it is practically impossible to borrow, steal or formulate the identity of an individual [1]. Biometrics are distinctive human measurable characteristics applied as a means for identification and authentication. It includes the use of various behavioral and physical identifiers. Examples of biometric techniques include facial recognition, finger-scan, Hand-scan, and retina-scan. Biometrics based on behavioral traits include: signature-scan, voice-scan, etc. Thus, the integration of software and hardware for the purpose of conducting identification or authentication based on biometric parameters constitutes a "biometric system" [2]. Most biometric data must be collected using special devices such as fingerprint scanner, palm print scanner and DNA analyzer. Targeted organizations should contact the required agencies during the data collection phase. The advantage of this system is that facial recognition does not require touching any device. The face is automatically detected using face detection technology, and facial recognition is fully completed without touching any device. Generally, facial recognition algorithms go through four stages: detection, analysis, comparison, and facial recognition, each of which is divided into several stages [3]. Human face detection and identification is significant, and is an active topic of research in information science and technology. Paul Viola Jones and Michael Jones presented a method for face detection in 2001. It was the first approach to give better object discovery rates. Today, Viola Jones is a very popular and effective technique. It requires very little computation time with very high precision. In addition, it is a fast and powerful algorithm used for face detection. MATLAB Computer Vision Toolbox contains several functions of the object detection algorithm of the Viola Jones algorithm, the first real-time face detection system [4]. Current face recognition techniques are for the most part appearance-based. Initial research on the application of principal component analysis (PCA) to face images was carried out by Kirby (1987) and Kirby and Sirovich (1990). They demonstrated that face reconstruction can easily be done through few eigen vectors, and showed that PCA is an optimal compression scheme [5]. Building on the work by Kriby and Sirovich, Turk and Pentland (1991) utilized a set of eigenvectors called eigenfaces for databases of images using PCA for face detection. Compressed Images were mapped into a database to which test images were then matched by projecting or mapping them onto the basis vectors [6]. Several techniques that create spatially localized feature vectors exist which aim to apply recognition by parts and be less prone to occlusion. The common way to do this is by implementing independent component analysis (ICA) which produces statistically independent basis vectors. ICA can also be used to create the feature vectors that distribute data samples in a uniform manner [7][8]. Another study utilized facial recognition for security purposes, namely providing identification and verification of individuals as part of an office security system using LabVIEW-based face recognition. This system uses a histogram as a feature for face recognition. However, this is considered to have poor accuracy [9].

METHODS

VIOLA–JONES Detection Algorithm

The Viola and Jones algorithm is used as the basis for our designed system. Since there are similarities in all human faces, we used this concept as a characteristic of Haar to discover the face picture. The algorithm searches for a specific Haar characteristic for the face, if this characteristic is found, the algorithm passes the filter to the next step. Since the filter is not a complete image, only a rectangular part of this image known as the 24x24 pixel pane is passed. With this window algorithm, the system can check the entire image

1. Haar Features

We use this concept to create the Haar function. It consists of two or three rectangles. These functions are applied to the face filter to see if the face is present or not. Each Haar entity has a value, which can be calculated by taking the area of each rectangle by adding the result. Using the concept of an integrated image, we can easily find the area of the rectangle [10].

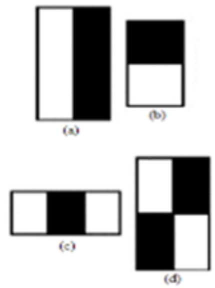

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Figure1. Viola Jones Haar like features.

Sum of the rectangle ABCD = D - (B + C) +A

2. Creating an Integral Image

The embedded image is the sum of the pixel values of the original image. To do this, each pixel is equal to the sum of all the pixels above and leaves for associated pixels [10].

1	1	1
1	1	1
1	1	1

Original Image

1	2	3
2	4	6
3	6	9

Integral Image

Figure 2. Transform original image into an integral image.

The integral image at location x, y contains the sum of the pixels above and left to x, y

$$\mathrm{I}, \mathrm{I}(\mathrm{x}, \mathrm{y}) = \sum \mathrm{i}(\mathrm{x}`, \mathrm{y}`) \qquad (1)$$

$$X` \leq x, y` \leq y$$

where *I, I(x, y)* is the integral image and *(x, y)* is the original image.

3.AdaBoost Training

A workbook is created using AdaBoost to define the small characteristics of the user's face quick and easy calculation. AdaBoost provides the desired area of the object. The basic idea is to create a complex workbook using a linear combination of a weak workbook [10].

1. $h(x, f, p, \Theta) = \{1, \ \ if(x) < p\Theta \qquad (2)$

0, otherwise

where x is 24×24-pixel image, θ is a threshold parity.

AdaBoost contains n training sets which have n number of pairs (x_i, y_i), where x_i is a +ve or -ve image and y_i is a label for each image is equal to 1 for positive image and -1 for negative image.

4.Cascade

We can quickly remove the wrong filter using the next step. Cascade has the filter if it does not pass the first floor. If it goes from sending to the next step which is more complicated than the previous one. If the filter passes each stage, it means that the face has been detected [10].

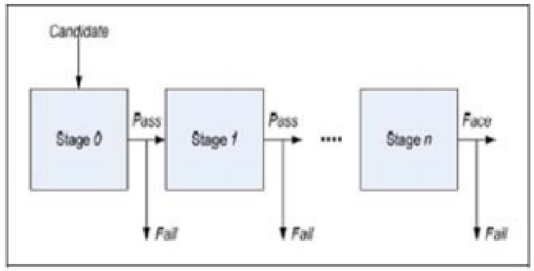


Figure 3. Cascade of stages, Candidate must pass all stages in the cascade to be concluded as a face.

The Principal Component Analysis (PCA)

A PCA called Karhunen-Loeve is one of the popular strategies to include the selection and reduction of measurement. Human faces were first identified with PCA by Turk and Pentland [11]. and human faces were removed by Kirby and Sirovich [12]. The basic idea in PCA is to solve the problem of large space in the small space. Recognition technology, known as the clean face strategy, characterizes the space of elements that reduces the dimensions of the first information space. This information has decreased. Space is used for recognition. In all cases, the low power of separation in the classroom and the mega-calculus are the main outstanding issues in PCA technology. This restriction has been exceeded by Linear Discriminant Analysis (LDA). LDA is the most popular choice calculation in appearance-based technologies [12]. One of the simplest and most effective PCA approaches used in facial recognition systems is the so-called clean face approach. This approach transforms faces into a small set of basic properties, the eigenfaces, which are the main components of the primary set of learning images (learning set). It is identified by displaying a new image in the clean-sided subspace, after which the person is categorized by comparing their location in the clean-face space with the position of known individuals [11]. The advantage of this approach over other facial recognition systems is its simplicity, speed and insensitivity to small or progressive facial changes. The problem is limited to files that can be used to recognize a face. These are images that must be vertical frontal views of human faces.

The entire recognition process consists of two steps:

1. Initialization process
2. Recognition process

The Initialization process involves the following operations:

(a) Acquiring the initial set of face images called as a training set.

(b) Calculating the clean faces from the training set and keeping only the highest eigenvalues. These M-images determine the area of the face. When new faces are faced, clean faces can be updated or recalculated.

(c) Calculating the distribution in this M-dimension area for each known person by displaying face images on that face area.

These operations may be performed from time to time whenever there is available operating capacity. This data can be stored in the cache that can be used in additional steps to eliminate the overhead for reformatting, which reduces the execution time and thus increases the performance of the entire system [10]. After configuring the system, the following process includes the steps:

(a) Computing a set of weights based on the input and image of M's external surfaces by removing an image input on both Eigenfaces.

(b) Determining whether the image is a face (known or unknown) by checking if the image is close enough to "free space".

(c) If it is a face, you must rank the weight pattern as known or unknown.

(d) Updating clean faces or weights as known or unknown. If the face of the unknown person is seen multiple times, then calculate the distinctive weight pattern and incorporate it into known faces.

Eigenface Algorithm

The Eigen space is calculated by specifying the eigenvectors of the covariance matrix derived from a set of learning images. Each image is stored in an *N* Eigen-space vector which comprises the following steps:

1. Let the set of facial images be [T_1,T_2,T_3,..,T_N] with *m* rows and *m* columns representing these images in dimensional column vectors (m^2 x 1). The images are centered by subtracting the average image from each vector of the image. You must calculate the average facial image ψ of these vectors such as,

$$\Psi = \frac{1}{N} \cdot \sum_{i=1}^{N} \Gamma i \qquad (3)$$

2. After calculating the median image of the face, the distance of each face image from the median image must be calculated as Φ_i a "column vector",

$$\Phi_i = (\Gamma_i - \Psi) \qquad (4)$$

3.Φ_i column vectors are gathered in matrix D = [Φ_1, Φ_2, ...,Φ_N] with dimension (m^2×N).The data matrix D is multiplied by moving it to calculate the covariance matrix C formed as,

$$C = D \cdot D^T \qquad (5)$$

The calculation m^2 of the spontaneous m^2 eigenvalues in the corresponding dead and square energetic compounds in the matrix C involves a great complexity of computation, to avoid this complexity as indicated in Turk and Pent land[13]we can choose the matrix of variation C in the dimension (N×N),

$$C = D^T . D \qquad (6)$$

4.In this step, we calculate the eigen values N (λ_k) and N eigenvectors (λ_k) of *C* to form Eigenface space. V = [v_1, v_2, . . .,v_N] Matrix comprising eigenvectors of *C* represented with dimension (N×N). We can obtain Eigenface space $U = [u_1, u_2, \ldots, u_N]^T$as follows:

$$U = V \cdot D^T \qquad (7)$$

All vectors in row U are "clean faces" for facial images in the training set. Facial images with higher subjective values have a greater contribution to the area of the electronic interface. For this reason, with low systems, the mathematical ability sorts the eigenvectors for the facial images according to their corresponding eigenvalues in descending order and chooses the first *Z* eigenvector to create a smaller clean area.

5. Matrix$W = [w_1, w_2, \ldots, w_N]$with dimension (N×N) includes the *N* vector column corresponding to each face image in the learning set. These vectors are called "characteristic vectors" and represent the specific properties of each image. Thus, *W* can be written as,

$$W = U \cdot D \qquad (8)$$

After obtaining the clean face space and feature vectors, we can compare a test image with the faces of the learning set through the following steps:

(a) T_TIs the column vector which represents our test image with (m^2 ×1) dimension. At this stage, distance of test image from mean face image should be calculated as Φ_T column vector,

$$\Phi_T = (T_T - \Psi) \quad (9)$$

(b) After calculating T_T,We have to show it on our own space to get its feature vectors in column vector format$w_T$with dimension (N×1),

$$w_T = U \cdot \Phi_T \quad (10)$$

(c) Now select the face category that best describes the input image. This is done by reducing the Euclidean distance

$$\varepsilon_k = ||\Omega - \Omega_k|| \quad (11)$$

Independent component analysis (ICA)

Independent component analysis (ICA) is a statistical and computational technique for detecting the hidden factors that underlie groups of random variables, measures, or signals. PCA creates compressed data with minimum squared error because it connects input data using second order. But independent component analysis reduces second-level and top-level dependencies in input samples [6]. ICA is associated with Blind Source Separation (BSS)[7], where the goal is to divide an observed signal into a linear set of independent, unknown signals.

In the simplest form of ICA, there are m scalar random variables x_1; x_2; ....; x_m to be observed ,which are assumed to be linear combinations of n independent components s_1, s_2, ...,s_n. The independent components are mutually statistically independent and with zero mean. We denote the observed variables xi as a observed vector $X=(x_1,x_2,............x_m)^T$ and the component variables Si as a vector

$S=(s_1,s_2,.........s_n)^T$. The relation between S and X can be modeled as

$$X = AS \quad (12)$$

Where A is an unknown m×n matrix of full rank, called the mixing /feature matrix. The columns of A represent features, and $s_i$signals the amplitude of the feature in the observed data x. If the independent components s_i have an unit variance, i.e., $E\{s_i s_i\}=1$; i=1, 2....... n; it will make independent components unique, except for their signs.Applying the ICA on face recognition, the random variables will be the training face images. Let $\grave{X_i}$ be a face image, we can construct a training image set $\{\grave{X_1}, \grave{X_2}, ... ,\grave{X_m}\}$ with m random variables which are assumed to be linear combination of n unknown ICs, denoted by $\{\grave{S_1},\grave{S_2},........,\grave{S_m}\}$For all i, i=1; 2; .... ; m;the image $\grave{X_i}$ and the independent component $\grave{S_i}$ are converted into vectors x_i ands_i by row concatenation and denoted as $X = (x1; x2; ………. ; xm)^T$ and $S = (s1; s2; …… ; sn)^T$, respectively. Note that the relation between S and X can be modeled as X =AS. From this relationship, each face image $\grave{X_i}$ is represented by a linear combination of s_1; s_{21}; ...... ;s_n with weighting a_{i1}; a_{i2}; .... ;a_{in}. Therefore, the feature/ mixing matrix A can be considered as the features of all training images**.** The feature representation is based on only the features in A. Bartlett and Sejnowski[7], make use of this representation for face recognition. This representation is straightforward and simple but has two limitations. First of all, given a vector X; the determined matrices A and S are only approximation using the 1xed-point algorithm.

This means, the feature matrix A may not accurately represent the training images X. Instead, X is approximated by the dot product of A and S. The second limitation is that this representation is hard to represent face images outside the training set[14].

RESULTS AND DISCUSSION

The experiment is performed using face database that includes pictures of employees in the examination office at the university, where we took this picture by Samsung Galaxy S10 phone with a 16-megapixel camera. Viola-Jones face detection method is used to detect the location of the face in an image, Then the MATLAB algorithm is used to find and locate the face and crop the image.

All training images are reshaped and converted into 200x180 grayscale images by using resize and rgb2graymatlab built-in function. show Figure 4.

The database contains 10 individuals with each person having ten frontal images. Figure 5 shows some of the sample face images from this database. There are variations in facial expressions such as open or closed eyes, smiling or non-smiling, and glasses or no glasses. We select 70 samples (7 for each individual) for training. The remaining 30 samples are used as the test set.

First we applied the ICA algorithm where the training images were entered and identified. And then they are stored in the image database as we explained previously, after that the test images are entered to evaluate the performance of the algorithm.

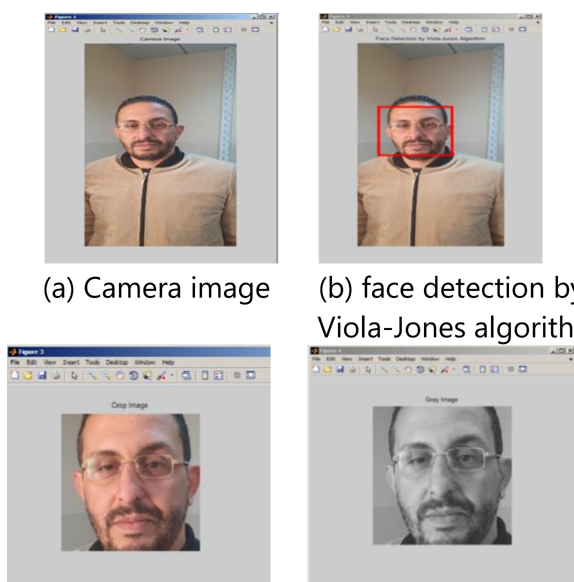
When the test data is entered to the algorithm, the algorithm creates a match between the test image and the images stored in the sample database, where 26 people were identified out of 30.

Then we compared the performance of the ICA algorithm with that of the PCA algorithm by applying the second to the same sample where 23 people were identified, and the figure shows the introduction of the same images that were tested with the previously ICA algorithm, but the result is a wrong definition

And the results were as shown in the figures (6) and (7).

The recognition accuracy of the two algorithms was calculated, which is the number of recognized samples divided by the total number of samples results are tabulated in Table1

In finally concludes that Independent Component Analysis (ICA) is better than Principal Component Analysis (PCA) in some cases, but requires at least few seconds as its training time.



(a) Camera image

(b) face detection by Viola-Jones algorithm

(c) Crop image

(d) gray

Figure 4. Processing image for recognition

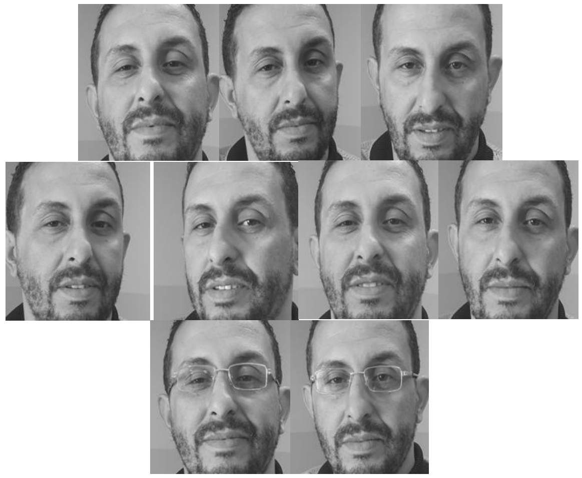
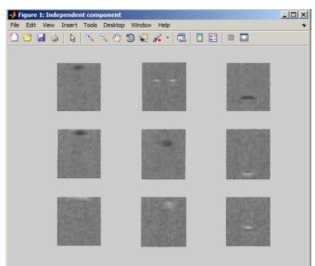
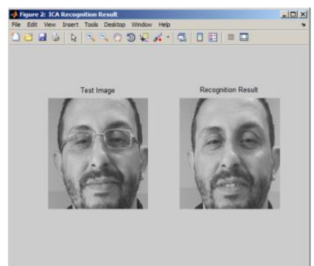


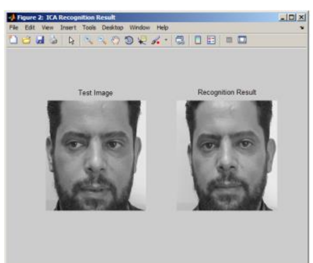
Figure 5. Sample photos of one person



(a)



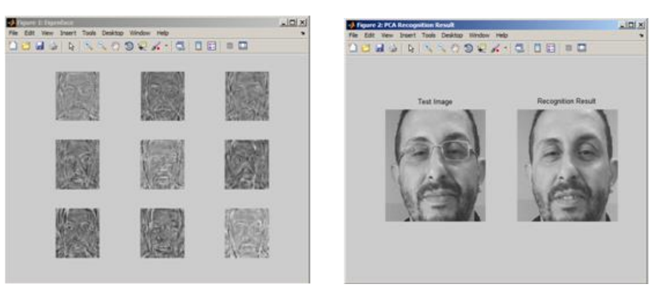
(b)



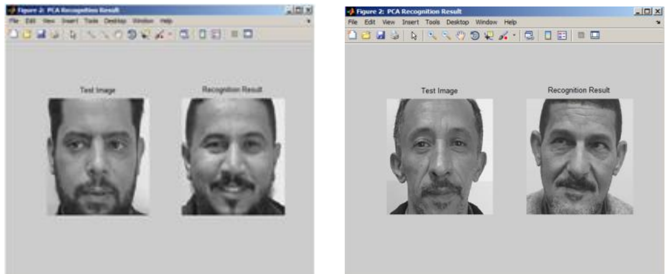
(c)

(d)

Figure 6. (a) Independent components for the images. (b),(c) and (d) Experimental Results ICA recognition



(a) (b)



(c) (d)

Figure 7. (a) Eigenfaces for the images (b), (c) and (d) Experimental Results PCA recognition

Table 1. Recognition Accuracy of algorithm

Algorithm	Recognition Accuracy
PCA	76.7%
ICA	86.7%

CONCLUSION

In this article, we implemented facial recognition algorithms for a security system for the Office of Study and Examinations at Omar Al-Mukhtar University (OMU). We took 10 different photos (because only 10 people are allowed in to protect the security of the exam system). The algorithm was tested and implemented in the Image Database of Study and Test Office using MATLAB. A comparison was made on the same sample using the PCA algorithm, the results were less accurate, and this finally concludes that Independent Component Analysis (ICA) is better than Principal Component Analysis (PCA) in some cases, but requires at least a few seconds as is training time. The face recognition-based presence system achieves the expected goal, but the accuracy of the face recognition still needs improvement. The fingerprint will be added to this system as an improvement and increase the efficiency.

Disclaimer

The article has not been previously presented or published, and is not part of a thesis project.

Conflict of Interest

There are no financial, personal, or professional conflicts of interest to declare.

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