Face Acknowledgment using Principle Component Analysis (PCA) of Eigenfaces

Muhammad Sajid Khan, Andrew Ware, Abdullah Khan.

Abstract*: *Face acknowledgement is a biometric framework used to recognize or check an individual's identity against a dataset of images. In recent times, there have been several different approaches utilized to try to achieve high accuracy rates. This paper presents a system that enables an individual's identity to be determined based on a matching of their facial structure against a previously stored database. The matching compares the frontal view of the face with the two-dimensional images of the head already stored. In our system, the input image is sometimes enhanced using histogram equalization, before the matching takes place using the Euclidean distance between the face to be identified and those already stored. The developed acknowledgement system provides an accuracy of 97.5%.

Keywords*: *Identification, Acknowledgement, Recognition, Euclidean distance.

I. INTRODUCTION

Biometrics refers to the processes used to recognize, identify, and authenticate people based on their physical or behavioral characteristics. Biometric systems work by measuring an individual's biometric characteristics and then comparing them to those already stored. For example, security companies have used such systems to facilitate verification of an individual's identity and provide access control. These systems have included such techniques as voice, fingerprint, iris, face, and signature recognition. Biometric systems are often an effective means of securely storing and retrieving personal and confidential data through a means that does not require PIN codes, passwords, secret keys, or pattern combinations. Therefore, biometric systems reduce the risk associated with stolen and forgotten passwords, misuse of secret information and shoulder surfing.

Biometric systems can also help alleviate problems of security often associated with driver licenses, identity and credit cards, passports, and payroll systems. Biometrics can broadly be divided into two main categories based on the use of an individual's physical or behavioural attributes [1]. Physical biometrics are often used for affirmation purposes and include iris and retina scanning as well as fingerprint matching. Behavioral biometrics includes signature writing and walking style analysis, and is important in recognizing and verification, as well as the affirmation process [2].

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Advancements in biometric based security systems is driven in part by an increasing need to prevent unauthorized access to digitally stored data and illegal copying of digital media [3]. To address these problems, digital rights management (DRM) tools and techniques, which determining whether the user is eligible to receive the content they request, have been developed [4].The most suitable biometric for a given scenario is dependent on the various characteristics of the application being considered. However, the most applicable in many scenarios is facial recognition due to the number of unique features a face possesses [5].

One means of enabling 2D recognition of a human face is to use a multi-layer histogram consisting of filtering enhancement and distribution features from the histogram coordinates. Despite the significant research effort directed at resolving issues related to pre-processing, transformation of features, and local descriptors, such techniques still have low accuracy and slow response time. Moreover, such techniques only deal with one aspects of the face, for example pose, expression and lighting problems, and do not support the unconstrained challenges of system integration.

This paper articulates a new Principal Component Analysis (PCA) method for facial recognition, which facilitates a better recognition rate through image reconstruction. In the following, Section2 provides a summary of a literature review that helps provide an understanding of the method, while Section3 details the methodology that makes use of a novel Euclidian distance measurement and histogram equalization to facilitate the reconstruction. Section 4 respectively provides discussion n analysis of the results obtained and draw conclusions from the work.

II. RELATED WORK

Face acknowledgement is a difficult step in many biometric systems that require a high degree of accuracy. The large number of poses (such as smiling or frowning) and orientations that an individual's face may take contributes significantly to that difficulty. These difficulties may also be compounded by the medium – for example, image or video – used to record the facial image. While the automation of human face recognition and analysis started in the late 1960's [6], in the early days, face affirmation was limited to a 2D structure affirmation problem [7].

Eigenfaces were used first for machine affirmation of faces in 1991 [8]. Since then, many preprocessing techniques to help ameliorate such issues as lighting fluctuating have been developed.Much work related to face recognition has involved using properties such as size, position, outline and geometric shape of the head and its constituent components such as the nose, eyes, and lips. Face recognition has matured in several directions including tracking, detecting, comparing, matching and sweeping. Nowadays, Eigenfaces are the most comprehensively used system for face affirmation. One development has been the use of Principal Component Analysis (PCA) to reduce the dimensionality of Eigenfaces [9][10] which in turn leads to a reduction in computational requirements and an improvement in face recognition rates. Generally, PCA use has a two-stage process of training and classification. In the training stage, different PCA methods [11] are applied to the training data in order to construct the Eigenspaces that can be used for classification. In the classification stage, features are extracted from the eigenvalues and compared in terms of their Euclidian distance from each image in the database.

The face affirmation problem can be solved using a set of Eigenvectors consisting of the Eigenfaces formed from two-dimensional facial images. Eigenvectors are a popular means of facilitating face recognition in computer vision problems, as they improve accuracy and performance. Eigenfaces divide into three main categories. In the first category, termed holistic, the complete facial image is accepted by the recognition system before PCA is used to reduce its dimensionality using classifiers that include Support Vector Machines (SVM); probabilistic matching; Fisherfaces, Independent Component Analysis (ICA), that retain the characteristics of the dataset [12]. The second category consists of feature-based techniques where Markov models, dynamic architecture and pure geometry, are used to segment single features, such as the eyes and nose, when preparing the input images for classification [13]. The third category comprises hybrid approaches, sometimes referred to as modular Eigenface, where local features of the whole face are considered [14].

Eigenfaces are considered a distinct field of image processing techniques based on Principal Component Analysis (PCA). Principal Component Analysis (PCA) [15] is used in many analytical scenarios for data compression and to remove unnecessary information from images. In our system, PCA is used to decompose the Eigenfaces into sub-components that are "uncorrelated" where each image is stored as a vector consisting of features such as pixel values, length and magnitude direction. When a full-face image is to be identified, the PCA method will use these sub-components, rather than the whole image, to identify the best match. When inaccurate estimation of features occurs, PCA is one means of reducing data dimensionality and increasing the variances in order to improve the recognition rate.

(Figure1 shows the evolution Eigenface recognition rates [16][17][18][19][20][21] [22]). In our system, PCA gives the Euclidean distance between the input image and those already stored in the image database. Applying PCA to Eigenfaces enables the variation of features in the data to be determined during the training phase. Subsequently the testing phase involves the projection of data in such a way as to maximize the variance between the face images stored in the database and the input image in terms of the Euclidean distance between them. The Eigenspace, which constitute the image to be identified, is compared to the database images, with the one with closest similarity index being considered a match (see Figure02).

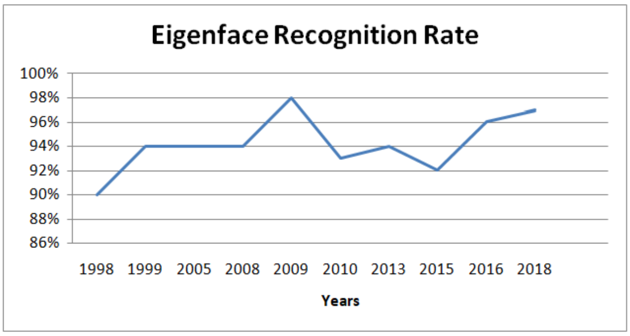

Figure1.The representation of the recognition rates over the period 1998 to 2018.

III. NEW SYSTEM FOR FACE IMAGE RECONSTRUCTION AND RECOGNITION

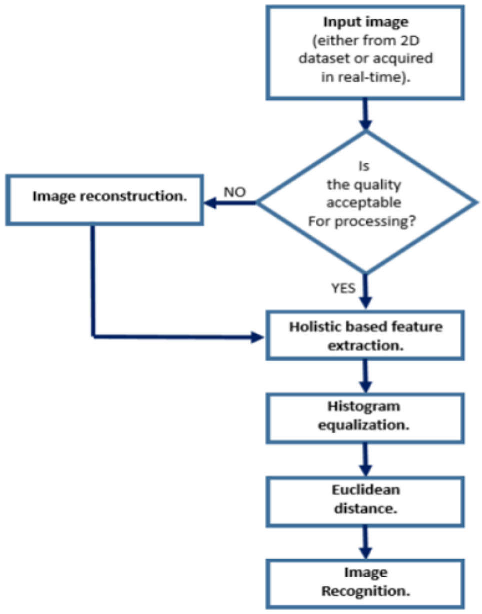

Figure2. Overview of method

The system is based on matching an image (acquired in real-time or extracted from the database) against all images in the database to determine the nearest match, if necessary low-quality images are automatically reconstructed using histogram equalization before the matching process is begun. After matching the next step is image preprocessing, where the image is prepared for reconstruction. Preprocessing removes unwanted data from the image and converts it from RGB to grayscale (see Figure3), and noise removal from the signature image through the application of the median filter [23]. Generally, this reconstruction and recognition pipeline results in a better recognition rate.

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Figure3.The conversion of color image into greyscale.

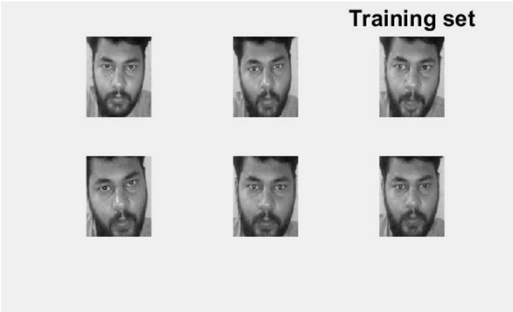

Figure4.Sample of training images of the same individual.

Each feature's structure will then be determined from the facial image (see Figure4) and stored in the database (see Figure5) for future use. During classification, the mean of all images (for the same face) stored in the database (see Figure6) is compared to the input image, to demine the most likely match.

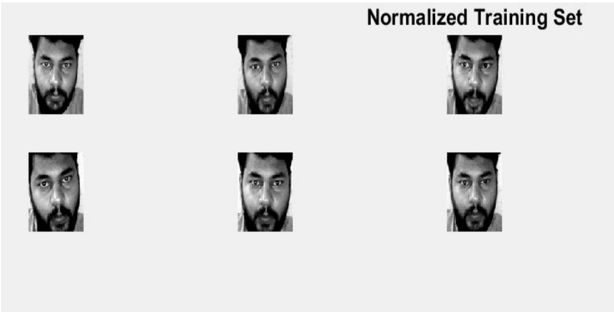

Figure5. Normalized training images from the datasets

Figure6. The mean image produced from all other images Of an individual

A. New Principal Component Analysis (PCA)

In the method developed, PCA is used to define the rules that determine segment examination [24] for the two-dimensional histogram using a strategy that extracts information from the processed image. The PCA is then used to find the eigenvectors of the covariance lattice with the most elevated Eigen values that are then used to extend the information into another equivalent subspace.

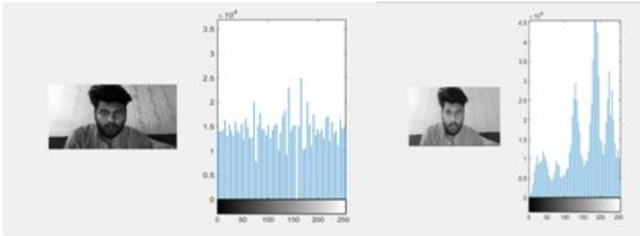

Figure7. Histogram of new image. Figure8.Reconstructed image.

The new image, shown in figure 7, is dark and of low quality. Moreover, its histogram does not adequately allow for the discrimination of facial features. The framework will consequently recognize the required changes and create a new image and histogram, thus iteratively improving the current image (see Figure 8).

B. Estimated Euclidean distance

After pre-processing the image, the next stage in the system is to determine the necessary information from the facial image. This information includes an estimation of the sample data from the subspaces of the checked image, and the coordinates and measurements that enable the face acknowledgement system. This system transforms the single face image to a vector space, which uses Principal Component Analysis (PCA) to locate a subspace for recognition. Only a few vectors traverse this subspace, which means that each face image can be characterized by a limited combination of coefficients weighting these vectors. To apply the PCA for the measurement of Euclidean distance (see Figure9)., the system selects the specific samples of data and finds the best subspace with respect to the intended sample data. This step is required only once, to determine the new points of data by projecting it onto the subspace and providing the measurement of the distance between its projection and Points.

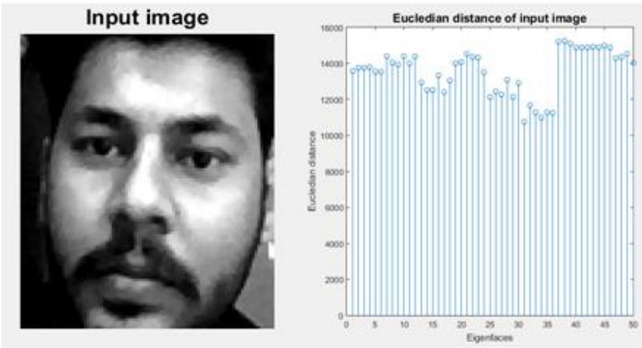

Figure9. Euclidian distance of recognized image

IV. RESULTS AND DISCUSSION

In the state-of-the-art method described, all images in the dataset are preprocessed and the input image is compared against them based on the Euclidean distance between them. If the input image is of poor quality, then it is first reconstructed using PCA in order to enhance its quality before compression takes place.

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In all cases, images are subject to the process of histogram equalization to ensure that they are consistent in intensity.The system described improves the accuracy rate achieved when identifying an individual from an image that is less than ideal. It does this by first reconstructing the image to improve its quality before attempting identification. As can be seen from figure 9, the results of the system compare favorably when compared with those obtained with a comparable methodology (see Figure 10).

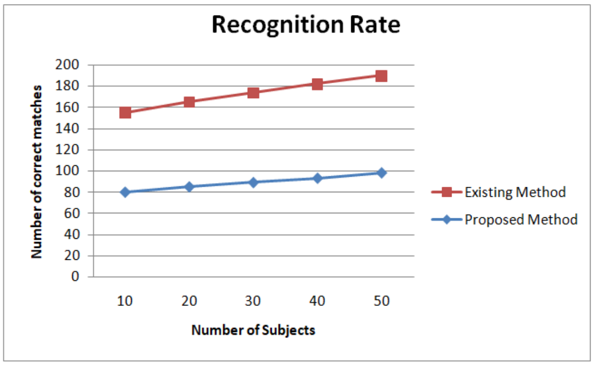

Figure10.The accuracy of new system and existing method [25].

V. CONCLUSION AND FUTURE WORK

In the state of the art method described, all images in the dataset are preprocessed and the input image is compared against them on the basis of the Euclidean distance between them. If the input image is of poor quality then it is first reconstructed using PCA in order to enhance its quality before compression takes place. In all cases, images are subject to the process of histogram equalization to ensure that they are consistent in intensity. In summary, the method consists of several distinct steps: image preprocessing, feature extraction to show recognized image, shows histogram of the reconstructed and poor image, and also show mean images from the database. Testing of the method, using black box testing, has shown that it produces better accuracy and performance when compared to existing methods. The work can be further transform into 3D reconstruction system by process of extracting features of Eigenface for 3D modeling; it can also be enhanced into 3D pose recognition system on the basis of Eigenface by introducing the new principal component analysis (PCA) to improve the recognition rate in 3D system.

CONFLICT OF INTEREST

The authors declare no conflict of interest.

AUTHOR CONTRIBUTIONS

Muhammad Sajid Khan conceived the research idea articulated in the paper and developed the framework.
Andrew Ware provided ideas for progressing the work and helped in the writing of the paper.
Abdullah Khan helped to tested and verify the results.

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