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Robust Face Recognition Algorithm with A Minimum Datasets

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ABSTRACT

In personal image recognition algorithms, two effective factors govern the system's evaluation, recognition rate and size of the database. Unfortunately, the recognition rate proportional to the increase in training sets. Consequently, that increases the processing time and memory limitation problems. This paper's main goal was to present a robust algorithm with minimum data sets and a high recognition rate. Images for ten persons were chosen as a database, nine images for each individual as the full version of the training data set, and one image for each person out of the training set as a test pattern before the database reduction procedure. The proposed algorithm integrates Principal Component Analysis (PCA) as a feature extraction technique with the minimum means of clusters and Euclidean Distance to achieve personal recognition. After indexing the training set for each person, the clustering of the differences is determined. The recognition of the person represented by the minimum mean index; this process returned with each reduction. The experimental results show that the recognition rate is 100% despite reducing the training sets to 44%, while the recognition rate decrease to 70% when the reduction reaches 89%. The clear picture out is the results of the proposed system reduces the training sets in addition to obtaining a high recognition rate.

1. Introduction

In biometric sciences, face recognition for humans is the most compelling issue based on personal identification[1,2]. According to modern technology requirements, the development in image and face recognition is a dynamic and frequent research field [3,4]. There are many advantages to human face recognition using biometrical authentication. The most important reason is the security field, such as secure facilities and sensitive places like airports, sports fields, and military sectors. The second reason is online commerce challenges such as shopping. The third reason is the biomedical identification of face recognition accuracy is high [5].

Nevertheless, Face images are light-insensitive, person, concealed, useful for biometric recognition, and are subject to variations [6]. Moreover, the training set's size limits the processing time, memory size and related directly to the recognition rate [7,8]. Thus, the relationship between the recognition rate and the size of the database is a crucial issue. PCA is a powerful method used as a tool for reducing orthogonal transformation data in the image process [9]. A large number of associated variables for dimensional data sets are reduced and preserved by PCA. Mathematically, the PCA formula is accumulated by the standard deviation, the eigenvectors, and the eigenvalues [10]. The classification process is used to estimate the difference between the database images and test images using distance methods like the typical Euclidean Distance method [11].

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A variety of methods are implemented to improve image recognition and reduce the database. A. Alkandari, S. J. Aljaber, 2015 [11], PCA implemented for recognition, identification of facial expression without human intervention. PCA is used to reduce the size of the matrix for image recognition. The authors suggested PCA for image recognition without considering the rate of recognition in the findings. I. Abbas, 2015 [12] presents an investigation of the impact of the different eigenfaces levels on the facial recognition rate using PCA. The analysis is based on 50 photos from the individual faces database (ORL), 40 photos as a training dataset, and 15 photos as a test group. The findings have shown that the proposed method is efficient. The identification rate is up to 100% by using ten proprietary applications. J. Jia et al., 2016 [13] proposed a PCA for feature extraction and a random forest algorithm. This algorithm could discriminate most emotions, such as outstanding, smiling, laughing in happiness, and shockingly shocking. E. I. Abbas, M. E. Safi, and K. S. Rijab, 2017 [14], proposed a personal recognition approach using PCA as feature extraction with different classifiers Euclidean Distance method. The Squared Euclidean Distance method and the City- Block Distance method are then clustering the training image difference with test image as persons for each technique to determine the recognition rate. Squared Euclidean Distance gives a recognition rate of 100%, while the rate 98% higher than the City-Block, which provides a recognition rate of 95%. Raja Abdullah Raja Ahmad et al., 2019 [15] proposed a multiple-stage reduction for feature extraction based on DCT and PCA. The Euclidean Distance classifier performs the classification process. The recognition rate reaches 100% for the full version of the training set (9 images). Nevertheless, the recognition rate decrease reaches 30%, reducing the database to 89%. E. Khansaa Dheyaa Ismael, Stanciu Irina, 2020 (Khansaa Dheyaa Ismael 2020), proposed a system for facial detection and recognition based on the Viola-Jones algorithm. In comparison, the system's database consists of 20 images for each person from live video stored in jpg format. The recognition step was performed by three models Fisher faces, LBPH faces, and Eigenfaces. Yet, the system is not working accurately with memory (RAM) less than 8 GB. Ryann Alimuin et al., 2020 [16] proposed a robotic security system based on FaceNet. The database consists of 200 sets (12x12 pixels) for each person, in addition to 10 images as test images. Yet, the recognition rate is only 50% when dealing with multiple persons. While 86% when dealing with single different faces.

2. The recognition method

The PCA is an effective algorithm that reduces the dimensions of face images, in addition to keeping the status of identifying data [17,18]. There are three steps to the mathematical method of PCA. The first step is to build a transformation matrix based on a face image training collection. The next move is to re-arrange the training of face images into vectors. Finally, the test feature vector is recognized by comparing it in the subspace of eigenfaces with the trained face images in the subspace of the Eigenface dataset [19]. As shown below:

a. Each face image X(x,y) has two dimensions (m×n) is re-arranged to be one-dimensional [20]. The average of the training set, as shown below:

$$\bar{X} = \frac{1}{N}\sum_{i=1}^{N} X_i \quad \dots\dots\dots \tag{1}$$

where: $\bar{X}$ is the mean, N is the length of the newly generated vector.

b. The covariance matrix calculated as:

$$C = \frac{1}{N}\sum_{i=1}^{N}(X_i - \bar{X})(X_i - \bar{X})^T \quad \dots\dots\dots\dots \tag{2}$$

c. The eigenvectors with respect to eigenvalues:

$$CV = \lambda V \quad \dots\dots\dots \tag{3}$$

where: V is set of the eigenvectors, and λ is the eigenvalue.

d. The resort of the Order's descends eigenvectors with the eigenvalues.

e. The mean for each value is that the image project is centered into Eigenspace

$$W_i = V_i^T (X_i - \overline{X}) \ldots\ldots \quad (4)$$

f. The mean of the test pattern should be centered like the training phase in the same Eigenspace.

g. The test of pattern, then compared with the database of the training set in the Eigen domain.

H- The recognition would be based on the minimum distance obtained when the identity hit was compared with the threshold.

The distance measurement is the last and vital step in image recognition. The image is converted into an Eigen domain and re-arranged as matrices. The similarity between the two face image matrices is determined by calculating the difference between the test pattern and the trained models.

Euclidean Distance technique: is a widely used technique for estimating similarity [21,22]. The Euclidean distance calculated by:

$$d(x, y) = \sqrt[2]{\sum_{i=1}^{l} (x_i - y_i)^2} \ldots\ldots\ldots\ldots \quad (5)$$

where x,y is the data set X. xi and yi are the ith coordinates of x and y, respectively.

3. Clustering of the similarity

The mean of distance calculates the clustering for test face image with respect to the training set images for each person as shown in the equation below:

$$D_p = \sum_{i=1}^{k} {d_i}/_{k} \qquad p = 1,2,..,P \ \ldots\ldots\ldots\ldots \quad (6)$$

where: k is the number of poses for each person P is the number of persons

Then construct a clustering matrix for all persons defined by $D_{clustring}$.

$$D_{clustring} = [D_1, D_2, \ldots, D_P] \ldots\ldots\ldots\ldots \quad (7)$$

The similarity of the test face image with the training database obtains by determined the index of the minimum elements in the clustering matrix.

$$\boldsymbol{D_{min}} = \boldsymbol{index}(\mathbf{min}(\boldsymbol{D_{clustring}})) \ldots\ldots\ldots\ldots \quad (\mathbf{8})$$

The final step of recognizing the test face image with the training database is specified by comparing the D_{min} with the threshold value.

4. The proposed system

The proposed algorithm for person recognition based on PCA with minimum clustering is shown in Fig. (2); the training data set is transformed into an Eigenfaces set, after which the trained set weights are calculated and stored in set W. The weights are estimated from that image for an unknown pattern X and stored in the Wx vector. As we mentioned before, PCA is an effective algorithm that reduces the dimensions of face images and keeps the status of identifying data [17,18]. Therefore, this study uses PCA as a feature for the person recognition classifier. The two vectors W and Wx are compared using the Euclidean Distance method, which is a simple technique to calculate the similarity. Especially similarity between the test image and each training image is required. The distance illustrates the similarity between the input pattern and the patterns in our training set. The proposed technique to calculate the clusters based on the mean for each distance Then construct a clustering matrix for all persons defined by $D_{clustring}$, as shown in equation (7). The similarity of the test face image with the training database obtains by determining the minimum elements' index in the clustering matrix, as shown in equation (8).

Consequently, the average person's clusters with these distances would specify the decision of recognition based on the threshold.

5. The experimental results and analysis

The training set and new face images are carefully chosen from the ORL database to reduce pose variation [23]. ORL database has different conditions such as changing poses, expressions, and facial details for comparison [25].

The selected database consists of 10 clusters; each cluster, as shown in Fig(1), represents one person; each cluster consists of 10 face images. The image was transformed for ease of processing into the Joint Photographic Experts Group (JPEG) format. For the training face set, normalization is used to minimize the errors due to the lighting conditions and background. As shown in Fig. (3), the Eigenfaces for the training are sorting set as descending forms of eigenvalues. The distance illustrates the similarity between the input pattern and the patterns in our training set. Consequently, the average person's clusters with these distances would specify the decision of recognition. Fig (4) illustrates the basic cycles of the experiment process, which is representing the experimental procedure for a data set redaction with respect to the recognition rate. The experiments were run using Matlab software. The analysis was checked for each data set redaction by applying the proposed algorithm shown in Fig. (2). The recognition rate change with data reduction was evaluated. The experimental procedure was ended at 89% of database redaction.

In comparison, table (1) illustrates the recognition rate with respect to the database reduction to minimize the database with an acceptable recognition rate related to the application. As shown in tables (1) and (2), the full training set consists of 9 images for each person (10 persons) with different poses. While the test for the algorithm reliability of recognition rate with respect to database redaction has two approaches; testing with pattern has the same pose in the training set and testing with the pattern out of the training set. The recognition rate for pattern testing is 100% for the same pose, despite database reduction to one image (89% of database redaction). Similarly, testing with the pattern out of training set poses has a recognition rate of 100%, even database reduction five images (44% of database redaction) after database reduction to 4 images (56% of database redaction), the recognition rate decreases to 90%. At the same time, the recognition rate is 80% for database redaction till two images (78% of database redaction). Finally, the reduction of one image for each person in the database (89% of database redaction) is 70%.

The clear picture is that the Proposed system has high recognition compared to the proposed systems in related works in terms of dataset reduction.

Figure. 1 The selected database [23]

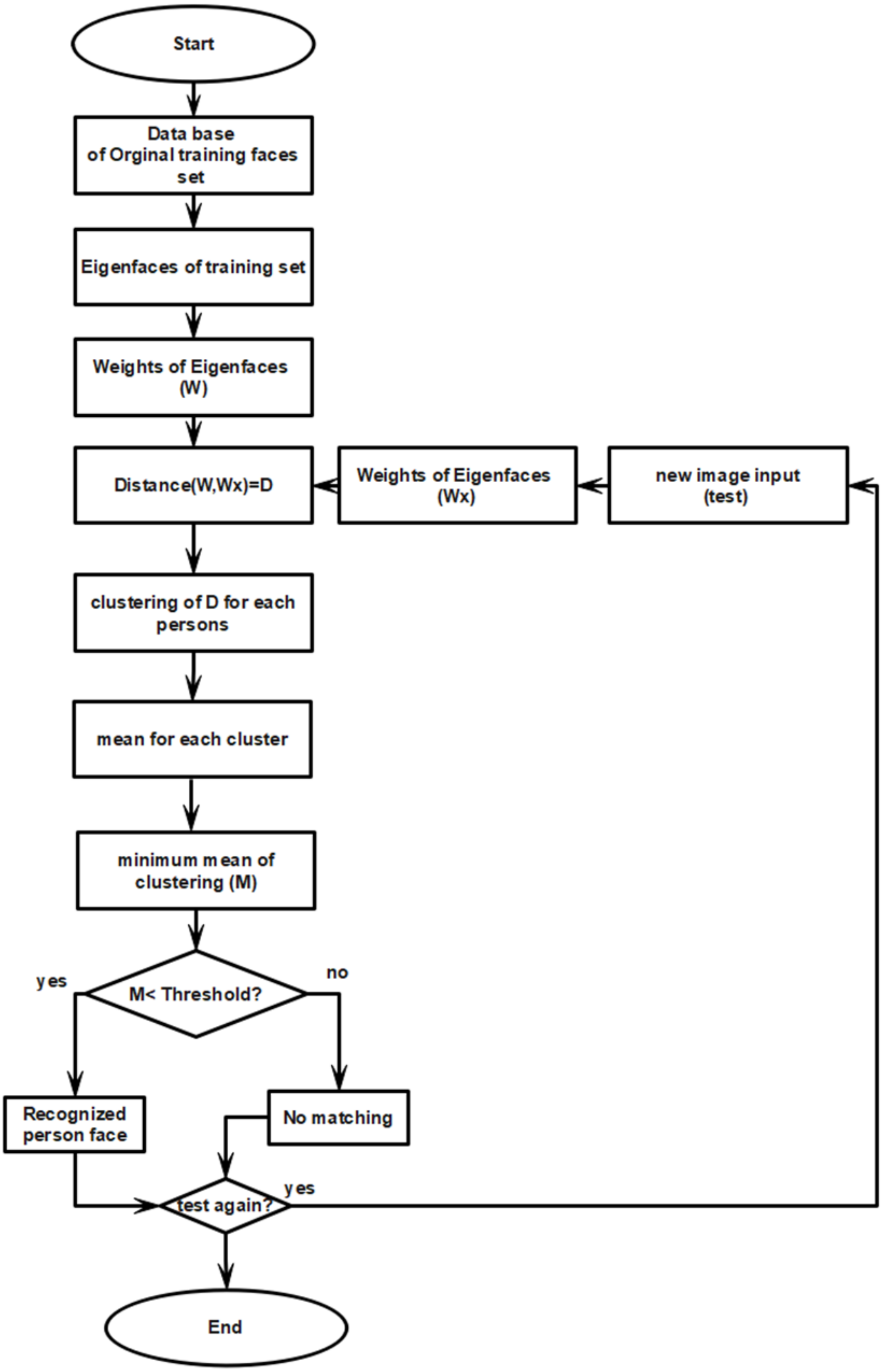

Figure 2. Flowchart of system algorithm

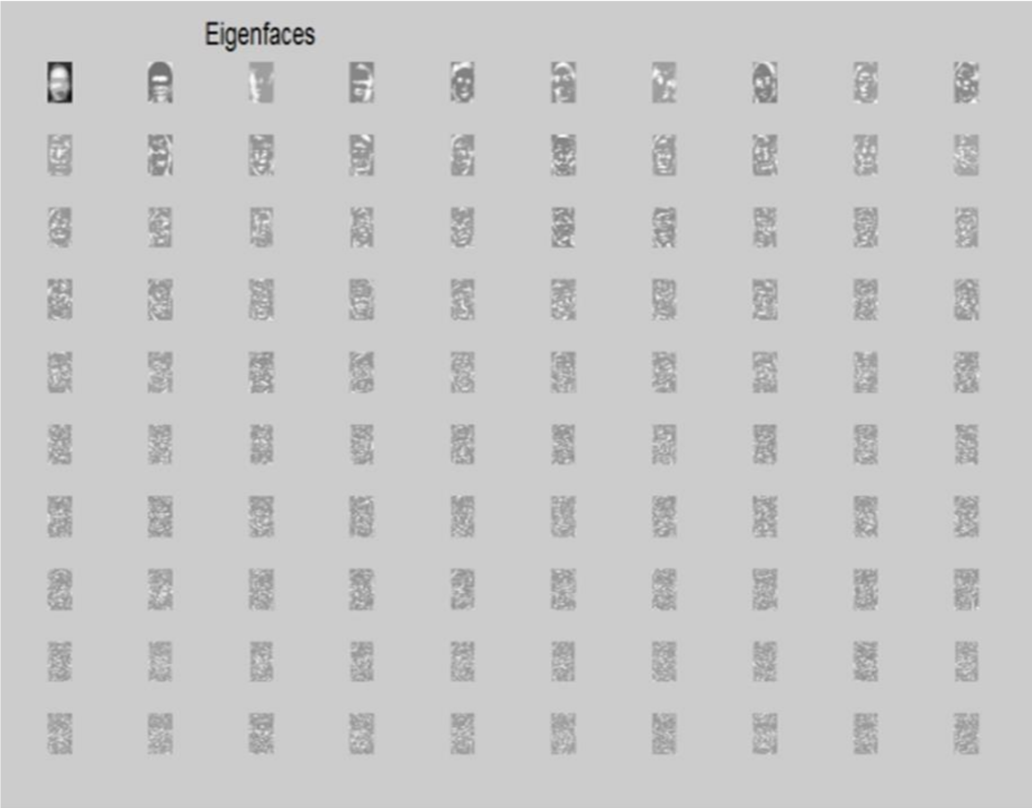

Figure 3. Eigenface ranked

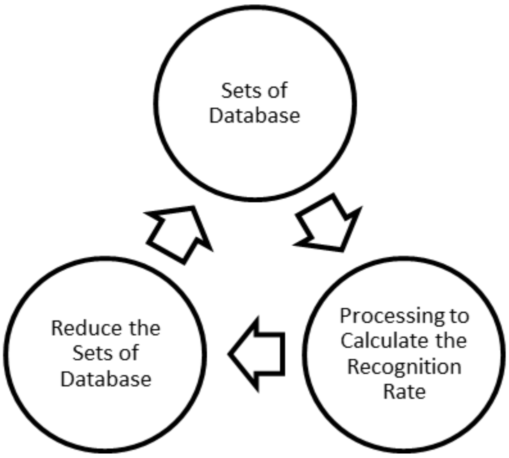

Figure 4. The basic cycles of the experiment process

Table 1: Recognition rate with respect to the database reduction

No. pattern in training set for each person	Recognition rate (With the same pose)	Recognition rate (With different pose)
9	100%	100%
8	100%	100%
7	100%	100%
6	100%	100%
5	100%	100%
4	100%	90%
3	100%	80%
2	100%	80%
1	100%	70%

Table 2: Recognition rate with respect to the database reduction percentage

Reduction of Data Base Percentage	**Recognition rate (With the same pose)**	**Recognition rate (With different pose)**
0%	100%	100%
11%	100%	100%
22%	100%	100%
33%	100%	100%
44%	100%	100%
56%	100%	90%
67%	100%	80%
78%	100%	80%
89%	100%	70%

6. Conclusion

Provide The biometric modal system proposed in this paper using PCA with the minimum mean of clustering. The proposed algorithm is fast, simple, and robust for the person Recognition process. Moreover, the algorithm has been shown reliability for database reduction. The experiment result has been offered a high recognition rate (100%) despite 44% of database redaction. Nevertheless, the decrease in a recognition rate to 70% with 89% for the database of the training set for testing with the pattern out of the training set, but still a good result in minimizing the training set with respect to recognition rate with corresponding to the application that uses this algorithm. In addition to the recognition rate, 100% for testing with the pattern has the same pose in the training set. The clear picture out is the results of the proposed system support the idea of the redaction of training sets in addition to obtaining a high recognition rate based on application requirements.

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