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Combined PCA-Daugman Method : An Efficient Technique for Face and Iris Recognition

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Authors' contributions

This work was carried out in collaboration among all authors. MMA designed the study, managed the data collection and literature searches, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. MARK supervised the work. ZUS, MU, SJS and TZK were co-supervisor of the work. All authors read and approved the final manuscript.

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Abstract

Face and iris are very common individual bio-metric features for person identification. Face recognition is the method of identification a person uniquely using face. Principal component analysis is one of the algorithms for face recognition. Iris recognition in another method of person identification using iris. Very popular iris recognition method is Daugman algorithm. Unimodal biometric system has various difficulties to detect a person like noisy and unusual data. Multimodal biometric system combined more than one individual modalities like face and iris to increase the efficiency. In this work, we combined principal component analysis and Daugman algorithm with ORL, YALE, CASIA and Real face dataset to combine face and iris recognition to improve the recognition efficiency.

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Keywords: Principal component analysis; daugman algorithm; face recognition; iris recognition; person identification.

1 Introduction

Unimodal biometric system is the system which uses only one individual feature to identify a person. There are some individual characteristics like face, iris and fingerprint etc. Face recognition [1] is an unimodal biometric system that utilizes face to detect a person. Facial recognition method normally used in various field like security and attendance. There are so many approaches [2] for face recognition such as principal component analysis, Discrete Cosine Transform, Locality Preserving Projections, Linear Discriminant Analysis, Gabor Wavelet, Independent Component Analysis, Neural networks and Hidden Markov Models and Fuzzy neural networks. Among these PCA Principal Component Analysis is very popular algorithm for face recognition.

Principal Component Analysis (PCA) [3], [4] is commonly used algorithm for face recognition process that uses eigen faces and eigen vectors to indentify person uniquely. Iris recognition [5] is another unimodal biometric system which utilizes iris of a person to detect properly. There are some common iris recognition algorithm [6] such as Daugman approach, Wildes approach, Li Ma approach, Tisse approach, LBP IN ADDTION TO LVQ method and Masek Method. Daugman algorithm is efficient and popular one for iris recognition method.

In Unimodal system, there are some problems like noisy data, non universality and intra-class variation. Due to these problems unimodal system generally do not cross the expected level of performance. Multimodal biometric system which combines mone than one individual features to detect a person more accurately. Multimodal biometric system can recover the lack of accuracy for unimodal bio-metric system.

In this work, we combined face recognition and iris recognition method to detect a person and to increase accuracy of identification using multimodal biometric system. For face recognition we used Principal Component Analysis with ORL, YALE and Real face dataset and for iris recognition we used Daugman algorithm with CASIA dataset. Therefore, we propose an efficient multimodal biometric technique called combined PCA-Daugman method.

There are few more chapters in this paper. Related Works at chapter II, Algorithms and Basic Terminologies at chapter III. Our working procedure at chapter IV, Calculation of results and Discussion section at chapter V and Conclusion at chapter VI.

2 Related Works

There are a lots of work based on face recognition and iris recognition. Some previous works with Principal Component Analysis and Daugman method are mentioned here.

In 2009 Jie Lin et al. [7] proposed a method for person recognition by the combining of iris and face. In this method, face recognition based on combined iris and face features for representing persons and then acts the modified PUM on these features for recognition. They previously applied the modified PUM method for face recognition.

In 2017, S. D. Jamdar and Y. Golhar [8] combined the features of face, ear and iris to multimodal recognition system. They introduced ear as the feature for multimodal biometric system and developed multimodal system by combining Ear, iris and Face recognition.

Y. Bouzouina and L. Hamami [9] in 2017 developed a biometric bimodal system for the identification of the person by combining the modality of the face and the iris. They also introduced face

recognition by using DCT and PCA transform. They used Snake method for the improvement of performance of the iris recognition by the precision of the segmentation.

In 2005, T. Ko [10] discussed some scenarios of multimodal biometric systems using fingerprint, face and iris recognition to improve recognition system accuracy and also discussed that the way to increase the image quality of fingerprint, face and iris for efficient multimodal biometric systems.

Azom et al. [11] proposed a hybridized fusion strategy in 2015 that combines face and iris based on feature and score level fusion using a decision level fusion rule using the ORL face and CASIA iris datasets.

In 2016, V. V. Dakre and P. G. Gawande [12] used a combination of face and iris biometric traits. They used Viola Jones algorithms for detection of face and circular Hough transform to segmented iris part in the image. they used Modular Principal Component analysis (MPCA) algorithm and 2D Gabor filter for feature extraction for face and iris respectively.

In this paper, we proposed a combined PCA and Daugman method for both face and iris multimodal recognition using the ORL and YALE, Real face dataset and CASIA image dataset to identify a person efficiently and to remove the limitations of unimodal system. The signification of our work is to work with real image dataset along with established image dataset comparing to the previous works.

3 Algorithms and Basic Terminologies

In this work, Principle Component Analysis (PCA), face recognition algorithm and Daugman method, iris recognition algorithm are combined to detect a person more efficiently than the unimodal recognition system.

3.1 Daugman's algorithm

Daugman's algorithm is very common and popular segmentation method for iris recognition.Using Daugman's algorithm, iris recognize process works efficiently. Applying an integro-differential operator the Daugman's algorithm is used to find the iris and pupil contour [13], [14]

$$\max\left(r, x_0, y_0\right)\left|G_\sigma\left(r\right) * \frac{\partial}{\partial r}\oint_{r,x_0,y_0}\frac{I\left(x,y\right)}{2\pi r}ds\right| \tag{3.1}$$

Where-
For each of pupil and iris:
(x_0, y_0) is center
and r is the radius of coarse circle
$G_\sigma\left(r\right)$ is Gaussian function and a smoothing function which indicates an edge
Δr is radius range
I(x,y) is original iris image
The Daugman's algorithm flowchart is shown in Fig. 1.

4 Methodology

There are so many commonly used and popular algorithms for face recognition and iris recognition separately, PCA and Daugman's algorithm are two of them. In this work, we combined principal component analysis (PCA) with the Daugman's method for the training of image datasets. We used four different image databases to experiment the accuracy of our proposed technique called combined PCA-Daugman method for multimodal face and iris recognition.

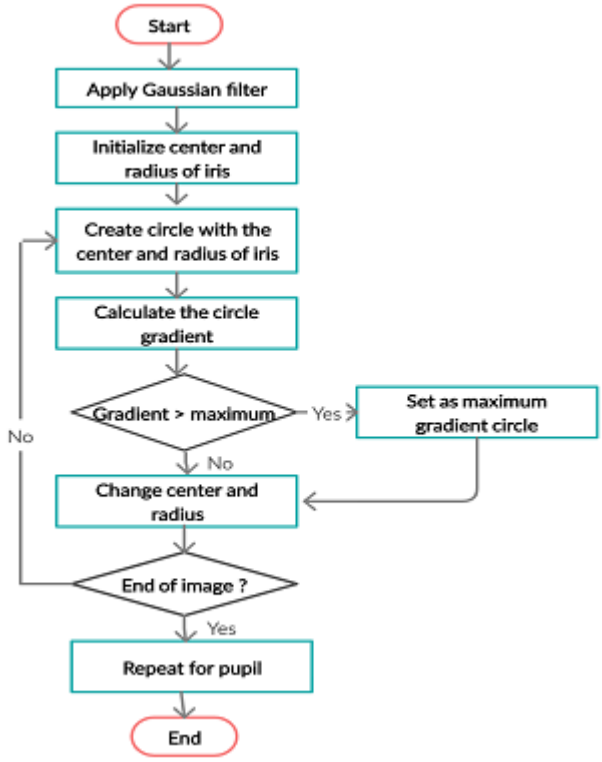

Fig. 1. Flowchart of Daugman's algorithm

4.1 Data Set

In this work, the experiment is performed on the four different image databases, among these three databases are face image database -

- ORL face database
- YALE face database
- Real face database

And another one is for eyes image database called -

- CASIA-IrisV1 database

ORL face database [15], [16] is the most applied face database in which 400 images are available of different 40 persons and for each person, there are 10 different images. There are many variations in expressions such as open/closed eyes, smiling/non-smiling, and facial details such as glasses/no glasses.

The Yale Face Database [17], [18] is commonly used grayscale image dataset which has total 165 images of different 15 individuals in GIF format. Each person has different 11 images, one per different facial expression: center-light, happy, left-light, w/no glasses, w/glasses, normal, right-light, surprised, sad, sleepy and wink [19].

In this work, very special thing is that there real face data set are used for experiment which is developed by us. Real face data set contains 300 images of 60 different persons with 5 different images each.

The faces of this data set is real and collected from our close juniors, seniors and friends. In this data set there are both male and female with different ages. In this data set the images have various expressions such as close and open eyes, with sun glass, hijab, beard and mustache.

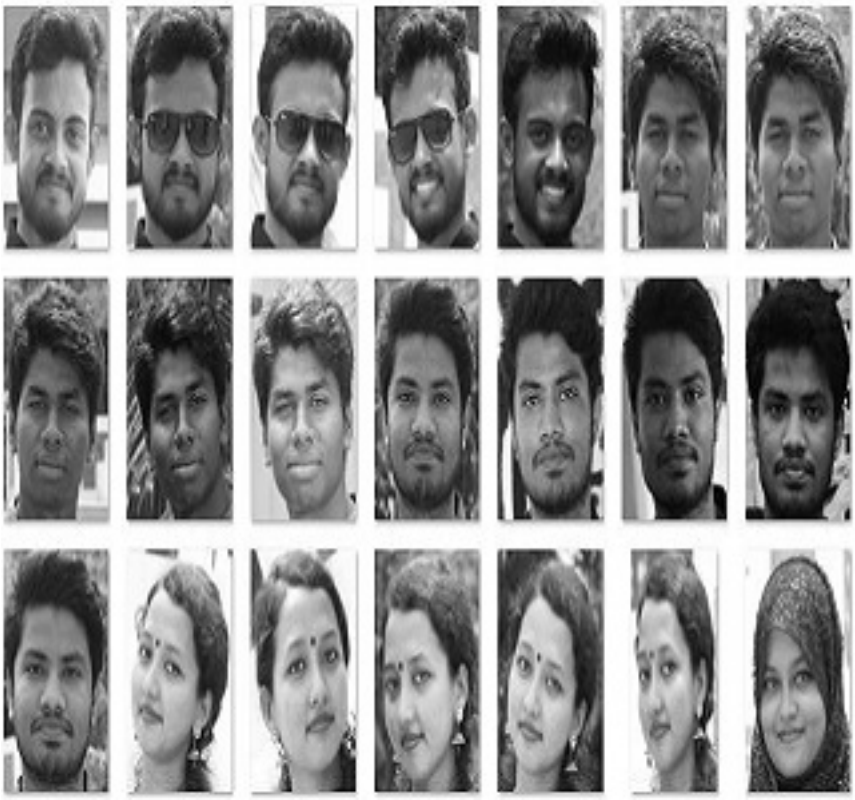

Fig. 2. Real face data set (partial)

CASIA Iris Image Database Version 1.0 (CASIA-IrisV1) [20] is very well known image database of 108 eyes with 756 iris images. Using CASIA close-up iris camera for each eye, seven images are captured in two different sessions. Three and four samples are captured in the first and second session respectively. And all images are in BMP format and resolution is 320*280. These three different data set which are used in this work make proper opportunity to compare the efficiency of this technique with the eifficiency of the traditional PCA algorithm.

4.2 Platform

For the implementation of combined PCA and Daugman algorithm we have used MATLAB software. It is very commonly used software for face and iris recognition process. This platform is also used also the face and iris image training and testing process of our work.

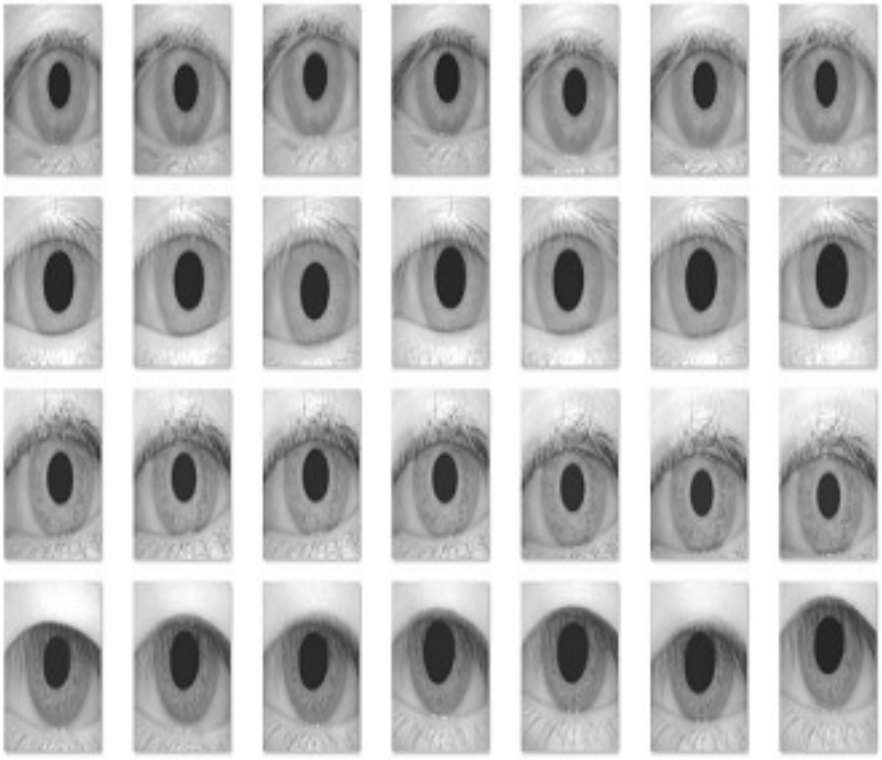

Fig. 3. CASIA Iris Image Database Version 1.0 (partial)

4.3 Method

The working procedure of combined PCA-Daugman's method are included face recognition and iris recognition. In these parts many operations executed like acquisition, processing, extraction, matching, normalization and combination.

The process of this work of combined PCA-Daugman method is depicted step by step by flowchart in Fig. 4.

Face Recognition: Principal Component Analysis (PCA) method for face recognition is used to extract features called 'Eigenface' from face images. Principal Component Analysis is used to the image databases of ORL, YALE and Real face database. The components used in this module are -

- Acquisition of Face Image: From database face images are loaded in this step.
- Pre-processing of Face Images: There are some operations in pre-processing stage like scaling, contrast and brightness being executed to make face database images compatible. Histogram Normalization is very well known pre-processing method used for face image.
- Feature Extraction: Principal Component Analysis is used for feature extraction to create a set of eigenfaces. The steps of feature extraction is described below:
  - Calculate mean image vector: Calculate the image vector and find the mean image vector by the number of images.

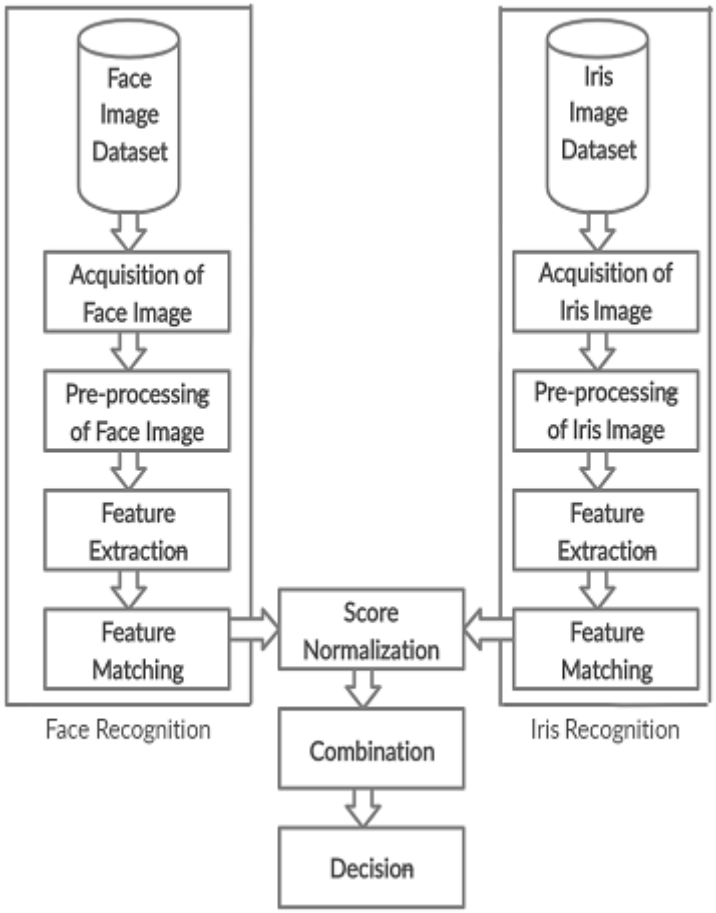

Fig. 4. Flowchart of Face and Iris recognition using Combined PCA-Daugman Method

- Subtract mean image vector from 1-D image vector : After calculating mean image vector, subtract the mean image vector from 1-D image vector.
- Calculate a convariance matrix: Calculation of a convariance matrix will help to calculate eigen values and eigen vector.
- Calculate eigen values and eigen vectors: Calculate eigen values using the convariance and identity matrix and calculate eigen vectors using the result of eigen values.
- Create a set of eigen faces: Create a set of eigen faces using the eigen values and eigen vectors.
- Calculate the Feature Vector: Calculate the weight/feature Vector for all images of Training set.
- Select a test image: An image is taken from testing images set.

- Feature Matching: The matching score is calculated using the euclidean distance between training and testing feature vectors. Matching scores of each test is stored to use for Combined PCA-Daugman approach of face and iris recognition.

Iris recognition: Daugman method for iris recognition is used for segmentation process on eye images. Daugman's method is used to the eye image database of CASIA. The components used in iris recognition are -

- Acquisition of Iris Image: From CASIA database iris images are loaded in this phase.
- Pre-processing of Iris Images: Iris localization and normalization are used for iris image pre-processing.Iris normalization, feature extraction and matching are depended on the accuracy of Iris localization.
- Feature Extraction: From normalized iris pattern features are encoded for both training and testing set of images using 1D Log-Gabor Wavelets. Encoded features are stored in the form of templates and masks.
- Feature Matching: The matching score is calculated using the hamming distance between training and testing templates and masks. Matching scores of each test is stored to use for Combined PCA-Daugman approach of face and iris recognition.

Face and iris recognition: Using the combined PCA-Daugman method, face and iris recognition works together which is our main purpose of this work. In this phase, the scores obtained from face and iris recognition phases are used combined. The components of this module are -

- Score normalization: For face recognition, PCA method is used for feature extraction and euclidean distance is used for calculation of matching score. For iris recognition, Daugman's method is used for feature extraction and hamming distance is used to find matching score. In this stage, both matching score is used to normalize the score using min max normalization technique with common domain and range.
- Combination: In this work, weighted sum rule of Score level combination technique is used.
- Decision: Combined score of face and iris final decision have taken place to identify a person.

5 Result and Discussion

Using the combined PCA-Daugman technique, the accuracy of multimodal face and iris recognition system for different datasets are different but obviously better than the accuracy of unimodal recognition using the PCA or Daugman algorithm separately. The accuracy is calculated by 30 epochs for random test images.

5.1 Result

The recognition performance for ORL and CASIA database are shown in Table 1.

Table 1. Face and Iris recognition performance for ORL and CASIA database

Methods	***Accuracy***
PCA (ORL Database)	97.68%
Daugman method (CASIA Database)	97.05%
Combined PCA-Daugman method (ORL-CASIA Database)	99.98%

The performance of face recognition for ORL database, iris recognition for CASIA database and both database for combined face and iris recognition is calculated on random choice test images. From Table 1 it is very clear that face and iris recognition accuracy Using Combined PCA-Daugman method is more efficient for ORL and CASIA database.

We calculate the performance for Yale dataset using the PCA, Daugman and Combined PCA-Daugman approach. The recognition performance for Yale and CASIA database are shown in Table 2.

Table 2. Face and Iris recognition performance for Yale and CASIA database

Methods	***Accuracy***
PCA (Yale Database)	86.60%
Daugman method (CASIA Database)	97.05%
Combined PCA-Daugman method (Yale-CASIA Database)	98.25%

From Table 2 performance on Yale and CASIA dataBASE is far better for Combined PCA-Daugman method than the unimodal PCA and Daugman algorithm.

The real face database consists of real images to check the performance of this approach. The recognition performance of PCA, Daugman and Combined PCA-Daugman approach for Real face Database and CASIA Database are shown in Table 3.

Table 3. Face and Iris recognition performance for Real Face and CASIA database

Methods	***Accuracy***
PCA (Real Face Database)	80.30%
Daugman method (CASIA Database)	97.05%
Combined PCA-Daugman method (Real Face-CASIA Database)	98.01%

80.25 98.12 From Table 3, Recognition accuracy Using PCA algorithm and Daugman method on Real face and CASIA database clearly is less than the Combined PCA-Daugman method.

5.2 Discussion

From the result analysis it is very clear that the person recognition performance using the combined PCA-Daugman method is better than the solo PCA and solo Daugman method. We experiment the combined PCA-Daugman method on four different image database like ORL, Yale, Real face and CASIA database. Accuracy of this method is very satisfactory over face recognition and iris recognition separately to identify a person. From the result it is clearly shown that this research methodology works well. So the Combined PCA-Daugman method is efficient for multimodal face and iris recognition.

6 Conclusions

The aim of this work was to develop a combined PCA-Daugman method which will provide better recognition result as a multimodal face and iris recognition. Our method provides a solution to recognize a person more efficiently using face and iris features. It is also able to identify a person

who have long beard and mustache and wear sunglasses or scarf. In future, we wish to use more extended and realistic complex image database and apply more dynamic and efficient algorithms to increase the accuracy and to reduce the complexities. We also wish to use advance artificial intelligence to make the recognition system more adaptable and reliable for the near future.

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Competing Interests

Authors have declared that no competing interests exist.

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