Iris Recognition based on PCA for Person Identification

Aniket S.Buddharpawar
PG Student
Department of Electronics
Walchand College of Engineering
Sangli,India

S.Subbaraman, PhD
Professor
Department of Electronics,
Walchand College of Engineering,
Sangli, India.

ABSTRACT

With over decade of intensive research in the field of biometric, security based applications havebeen developed. There are many biometric security systemsfor person identificationbased on palm print, face, voice, iris, etc. Many researchers have recommended PCA as an efficient algorithm for such applications due to its simplicity, accuracy, and dimensionality reduction on large dataset while retaining as much as original information as possible. This paper presents the details of PCA tool for analyzing patterns in images. This paper focuses on choosing iris as a biometric for identification since it is unique of a person and it remains unchanged over many years (throughout the life of a person). CASIA v1 database has been used in the studies of PCA for personal identification. PCA gives 85% accuracy by using Euclidean distance as a classifier.

Keywords

Principal component analysis (PCA), False Acceptance Rate(FAR), False Rejection Rate (FRR), Chinese Academy of Science Institute of Automation (CASIA).

1. INTRODUCTION

Biometric systems for personal identification are gaining wide spread acceptance from personal authenticity and system security point of view. These systems are based on various biometrics such as face, finger, palm, signature, voice, iris, etc. Iris based biometric is one of the efficient methods of personal identification due to the uniqueness of iris pattern typical of a person as compared to other biometrics[1][8]. Secondly, it has been reported by J. Daugman that iris pattern remains unchanged over many years of the life of a person [2]. Many researchers working in this area have recommended Principle Component Analysis (PCA) as one of the efficient algorithms to extract the features to be used further for pattern recognition [3][4]. In this paper iris as a biometric is chosen and used CASIA v1 database for developing and testing the PCA algorithm for personal identification [5].

Fig.1. shows sample image of the CASIA v1 database and structure of iris when seen from frontal section. The round contractile membrane between sclera and pupil is known as iris. This paper focuses pre-processing of such iris images to extract iris region efficiently by eliminating redundant information and maintaining variability. Process flow for overall recognition process is shown in Fig. 2.

The rest of the paper is organized as follows. Image pre-processing technique is described in Section 2 while details of PCA algorithm are presented in Section 3. The subsequent stage of Matching is discussed in Section 4. The results of personal identification using PCA extracted features of the pre-processed iris images are presented in Section 5 with conclusions in Section 6.

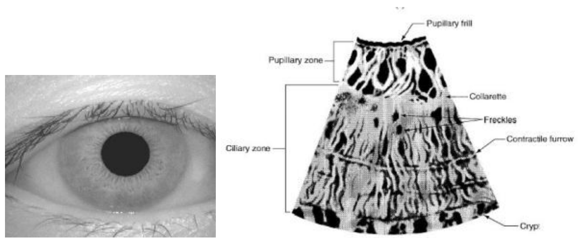

Fig.1: Eye Image and Iris Pattern

2. PRE-PROCESSING

Pre-processing is very important step in image processing. For perfect recognition of a system iris region should contain useful information [6][9]. The various steps of pre-processing include Image Thresholding, Segmentation, Normalization and Enhancement in the sequence as shown in Fig. 2. These steps are as described below.

2.1 Graying

A colored RGB image is converted to grey scale image. Grey scale images are help to detect edges by applying suitable threshold.

2.2 Iris inner boundary localization

As pupil is much darker than iris or sclera original image ‘I’ need to be converted to binary image ‘I_b’ to filter out pupil pixels. It helps to reduce search space for pupil boundary (iris inner boundary) only to dark pixel in the image. 3 x 3 Sobel filter masks in horizontal(‘Igh’) and vertical (‘Igv’)direction as shown below are applied on binary image, so that it further gives gradient image ‘Ig’.

$$I_g(x,y)=(I^2_{gh}(x,y)+I^2_{gv}(x,y))^{1/2} \quad (1)$$

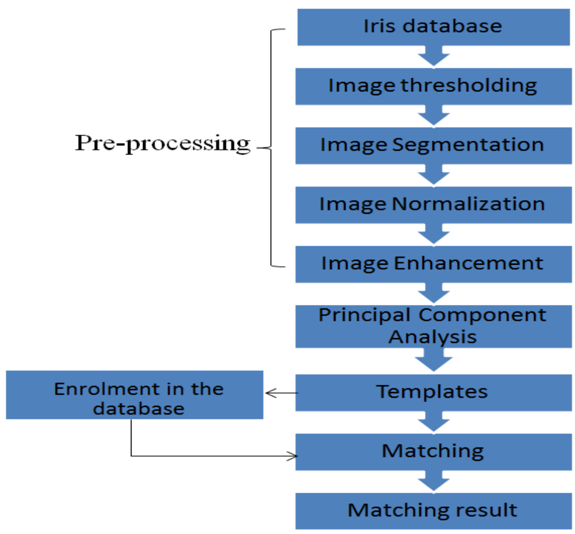

Fig. 2: Overall Iris Recognition Flow

Finally, 'I_g'is threshold to generate binary image 'I_{gb}'and difference on pixels boundary is highlighted. For detecting pupil center we have measure the maximum distance over orientation 'θ' of edge detected binary image 'I_{gb}' between two extreme ends of pupil and mark intersection of longest two lines as a center. Fig. 3 shows inner boundary detected eye image. Orientation of edge at any point (x,y) in I_{gb} is given by equationshown below.

$$\theta(x,y) = tan^{-1}(\frac{I_{gv}}{I_{gh}}) \qquad (2)$$

$$I_{gh} = \begin{bmatrix} -1 & 0 & -1 \\ -2 & 0 & -2 \\ -1 & 0 & -1 \end{bmatrix} \qquad I_{gv} = \begin{bmatrix} -1 & -2 & -1 \\ 0 & 0 & 0 \\ -1 & -2 & -1 \end{bmatrix}$$

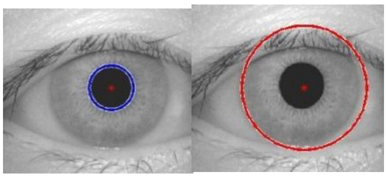

Fig. 3: Inner and Outer Boundary Detection

2.3 Iris Outer Boundary Localization

Inner boundary localization method is used in the work of this paper to guide outer boundary of iris. Since the contrast across outer boundary is less as compared to inner boundary an integro-differential operator is used to detect the outer boundary. While detection of outer boundary, noise present in the form of eyelashes, eyelids need to be removed. Hence, a Gaussian filter $G_\sigma(r)$ given by the following Eq. (3) was used over the original image to smoothen it.

$$G_\sigma(r) = \frac{1}{\sigma\sqrt{2\pi}} e^{\frac{-r^2}{2\sigma^2}} \qquad (3)$$

The pupil center and iris center need not be concentric but they are usually close to each other. Hence pupil center is used as reference to detect outer boundary and integro-differential operator were applied over thesector of the circle as equation below.

$$\max_{(r,x_0,y_0)} \left| G_\sigma(r) * \frac{\partial}{\partial r} \oint_{r,x_0,y_0} \frac{I(x,y)}{2\pi r} ds \right| \qquad (4)$$

Here, I(x,y) is the original image, 'r' is the radius from pupil center to search for iris boundary. And mark maximum change in pixels over contour ds.

2.4 Image Normalization

Normalization is a technique to prepare a segmented iris for feature extraction. A proper normalization technique is needed to compensate variations present in eye image. A Cartesian to polar coordinate mapping has described by J. Daugman and is called as rubber sheet model [1]. We also have used this model as shown in Fig.4 which remaps each iris region point to polar coordinate (r, θ)with 'r' varying in distance from 0 to 1 while θ is varying in angle from 0 to 2π. After few trial and error runs, 20 pixels to the left and right of iris in radial direction and 120 pixels in angular direction for template creation were standardized in our work. Fig. 5 shows derived iris template by using rubber sheet model.

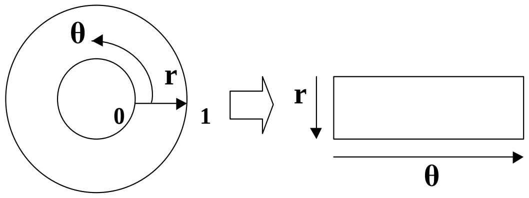

Fig. 4: Cartesian to Polar Coordinate Transform

The remapping of iris from Cartesian to polar coordinate system is modeled as given by equation 5.

$$I(x(r,\theta)), y(r,\theta)) \longrightarrow I(r, \theta) \qquad (5)$$

with

$$x(r,\theta) = (1-r)x_p(\theta) + rx_i(\theta)$$

$$y(r,\theta) = (1-r)y_p(\theta) + ry_i(\theta)$$

The coordinates of inner and outer boundaries along 'θ' direction are x_p, y_p and x_i, y_i respectively.

2.5 Histogram Equalization

The normalized iris template of Fig.5 has lot of variations present due to variations in light illuminations. For getting accurate features, image enhancement is required. By using histogram equalization, pixels intensities get spread over entire iris template. Fig.6 shows iris template with and without histogram equalization.

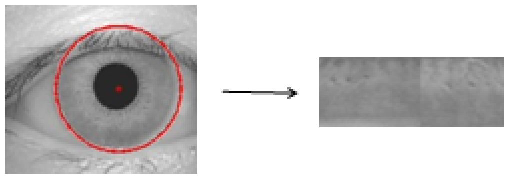

Fig. 5: Remapping of Detected Iris

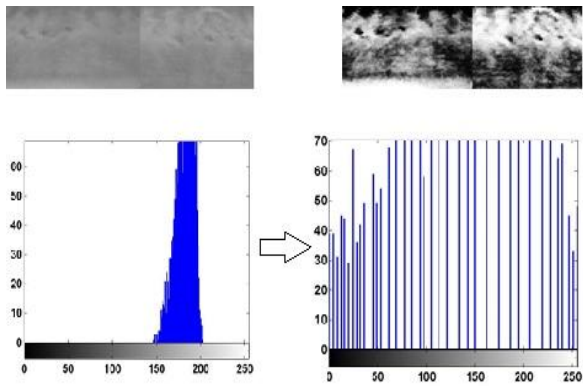

Fig. 6: (a) Iris Template without Histogram Equalization (b) With Histogram Equalization

3. PCA

PCA is among the most popular tool in machine learning, statistics, data analysis etc. It is used to extracts main variations in the feature vector and to reduce the amount of computation needed. It can also be used as dimensionality reduction tool that is used to reduce large set of variables to a small set that still contains most of the information of large set. PCA was invented by Karl Pearson in 1901. PCA is mathematical procedure that transforms number of correlated variables into a number of uncorrelated variables called Principal Components. The first principal component accounts for much of variability in the data as possible and each succeeding component accounts for as much of remaining variability as possible.

In the work of this paper, the features of the normalized iris template were extracted by applying PCA and finding out the feature vector for each iris image. Finally iris feature vector was transformed to original space called Eigen irises and distance was measured between test images with registered database images. The mathematical treatment of PCA algorithm is given below:

3.1 Mathematical Analysis of PCA

PCA identifies the strength of variations along different directions in the feature vectors. Iris images of 36 persons from CASIA database, with seven images of each person under different lighting conditions and camera orientation were selected. 2-D iris template obtained as above needs to be converted into 1-D. Suppose 'T' is the training dataset of iris templates of size (m x n) of 36 x 7 iris images.

The template of each iris of size (m x n) of each one of the 36 persons is converted into a column vector giving a matrix as below.

T={P01.1---P01.7p02.1—P02.7------P361----P367}

Where each of the row element is a column vector of size (mxn). The steps of PCA are as given below.

- The row wise mean is calculated.

$$m = \sum_{n=0}^{N} Tn \qquad \textbf{(6)}$$

Where, N is total number of registered iris templates.

- Mean is subtracted from each of the column vector to produce a set of zero mean vectors Ai given in Eq.(7).

$$A_i = T_i - m \qquad \textbf{(7)}$$

where,

'i' varies from 1 to N, Ti is training dataset of 'N' images.

- Covariance matrix 'C'iscalculated.

$$C = [A_i]^T * A_i \qquad \textbf{(8)}$$

- Eigen values and Eigen vectors are calculated using equation below

$$[C-\lambda I]e=0 \qquad \textbf{(9)}$$

where, 'λ' is the Eigen value and 'e' is the Eigen vector. 'I' is identity matrixwhich gives us N eigenvectors (e1, e2, e3…….eN).

- Each of the Eigen vector is multiplied with zero mean vector 'Ai' to form feature vector. The equation for feature vector is as follows

$$f_i = [A_i]*e_i \qquad (10)$$

After deriving feature vector matching of test image with training dataset is performed. Section 4 describes about matching stage.

4. MATCHING

In this paper, Euclidean distance classifier was used for matching purpose. Distance between test images with derived feature vector in training dataset is measured. A suitable threshold is selected to accept or to reject the test images. Images having distance above threshold are rejected. Following equation is used for calculating Euclidean distance.

$$E_k = || f - f_k ||^2 \qquad (11)$$

5. IMPLEMENTATION AND RESULTS

In the present work, pre-processing of iris images and extracting feature vector of each image using PCA algorithm was carried out in Matlab 13.0 environment. The iris detection percentage in the pre-processed images was more than 95. There were few noisy images present in the database which could not be detected for iris. Pre-processing results are given in Fig.7 Our technique for feature extraction works better as compared to other methods used by researchers [4].

By applying PCA algorithm and Euclidean distance as a classifier a matching rate of greater than 85% was obtained. Fig.8 shows screenshot for performance of our algorithm and testing of test image. Graph for FAR/FRR v/s threshold value over all dataset is shown in Fig. 9.

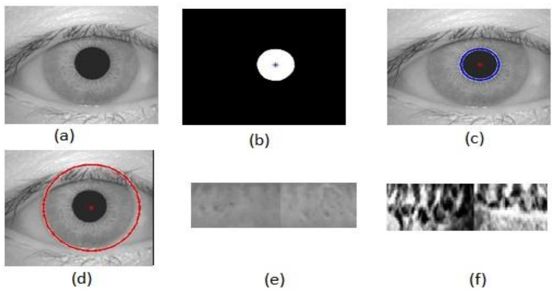

Fig. 7: (a)Original Image (b)ThresholdBinary Image (c) Inner Boundary (d) Outer Boundary (e) Iris Template (f) Histogram EqualizedTemplate

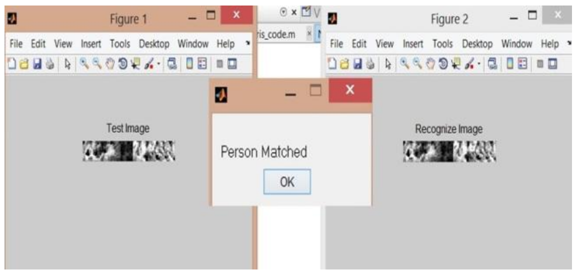

Fig 8: Results Obtained by Applying PCA in MatlabEnvironment

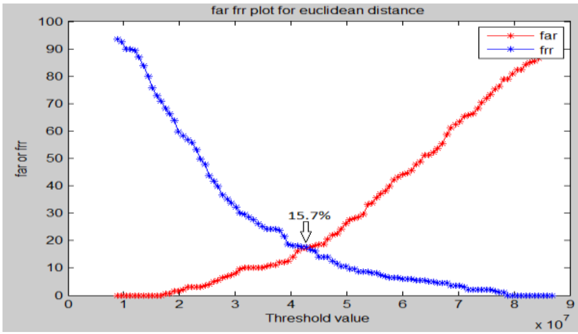

Fig 9: Error Rate for FAR/FRR Vs Threshold Value

From above Fig.9 it is seen that both FAR and FRR are threshold dependent. An optimum value of 4.5 for the threshold can be chosenfor about 15%FAR and FRR. 15%. This gives overall recognition accuracy of about 85%.

6. CONCLUSION

Principal component Analysis method has been used to extract the features of iris pattern for person identification. The pre-processing of iris images is carried out by the approach suggested by J. Daugman. An identification accuracy using Euclidean distance was found to be 85%. The pre-processing accuracy can be increased by using images captured in controlled environment while identification accuracy can be enhanced further by varying the size of the templates. These two facts need to be explored in detail as future scope.

7. REFERENCES

[1] Daugman, J., "How iris recognition works," Image Processing. 2002. Proceedings. 2002 International Conference on , vol.1, no., pp.I-33,I-36 vol.1, 2002.

[2] http://ngm.nationalgeographic.com/staticlegacy/ngm/0204/feature0/zoom8.html

[3] Morizet, N.; Amiel, F.; Hamed, I.D.; Ea,T.,"A Comparative Implementation of PCA Face Recognition Algorithm," Electronics, Circuits and Systems, 2007. ICECS 2007. 14th IEEE International Conference on , vol., no., pp.865,868, 11-14 Dec. 2007.

[4] Murugan A.,Savithiri G., "Feature extraction on half iris for personal identification," Signal and Image Processing (ICSIP), 2010 International Conference on, vol., no., pp.197,200,15-17 Dec. 2010.

[5] CASIAirisimagedatabase,http://www.cbsr.ia.ac.cn/IrisDatabase.htm.

[6] Zhijing Yang; Chunmei Qing, "A new iris recognition method based on PCA and sparse representation towards occlusion," Consumer Electronics - China, 2014 IEEE International Conference on , vol., no., pp.1,3,9-13April 2014

[7] Jin-Xin Shi; Xiao-Feng Gu, "The comparison of iris recognition using principal component analysis, independent component analysis and Gabor wavelets," Computer Science and Information Technology (ICCSIT), 2010 3rd IEEE International Conference on, vol.1, no., pp.61,64, 9-11 July 2010.

[8] Anil K Jain, Robert P W. Duin, and Jianchang Mao, “Statistical Pattern Recognition: A Review”, IEEE Transactions on Pattern Analysis and Machine Intelligence, 22(1):4 37, January 2000.

[9] Aditya Nigam at el, “Iris Segmentation using an Improved Hough Transform”.