Iris Detection Based On Principal Component Analysis-Eigen Irises

Dhananjay Theckedath

Abstract--**This paper describes the technique of personal verification and identification using Iris Patterns. It detects Irises based on the principal Component technique analysis. The Principal Component Analysis (PCA) is one of the most successful techniques that have been used in image recognition and compression. There has been a lot of work carried out on face recognition using the PCA. This paper tries to use the same concepts in trying to detect Irises.**

Identification starts with localizing the portion of the eye that corresponds to the iris. After localization, the iris is centre aligned with the image frame and unwanted portions of the iris occluded by the eyelids is removed. In order to minimize the time consuming pattern matching process of the input iris with each sample in the database, the input iris image is compared with database image based on ratio of limbus diameter to pupil diameter. Only if the diameter ratio matches, the input image is cross-correlated with database image to obtain correlation coefficients.

Index Terms-- **Biometrics, Co-variance matrix, Eigen vectors Eigen irises, Iris Recognition, Mean image.**

I. INTRODUCTION

THE conventional methods of personal identification are based on what an individual possesses. Earlier methods included things like personal identification number, Identity cards etc. All these methods had drawbacks, which are well documented [1]. Various biometric methods of identification and verification [6], [7] of person are proposed which include speaker recognition [2], face recognition [3], fingerprint recognition [4], Hand Geometry [6], [7],[8],[9],[10]. Iris recognition is new approach to person identification. Iris recognition is found to be a very accurate method of identification and verification of individual [5]. Among all biometric technologies Iris recognition becomes the hot topic of research pattern recognition for following reasons [8] 1) Iris is as distinct as fingerprint 2) it is stable with age [11],[12] 3) and is non invasive

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II. IRIS STRUCTURE

It is important to understand the structure of the Iris before proceeding to perform Iris detection. Iris is composed of several layers. Its posterior surface consists of heavily pigmented epithelial cells that make it impenetrable to light. The two muscles that control the pupil are anterior to this epithelial cell layer. Next layer called stromal layer consists of collagenous connective tissue in arch-like processes. Below this layer are the blood vessels. The most anterior layer is densely packed with pigment cells called chromataphores. The visual appearance of the Iris is due to this multi-layered structure. The colour of Iris is due to differential absorption of light falling on the pigmented cell.

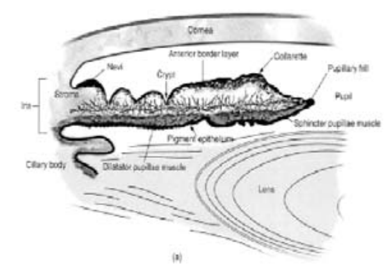


Fig.1a

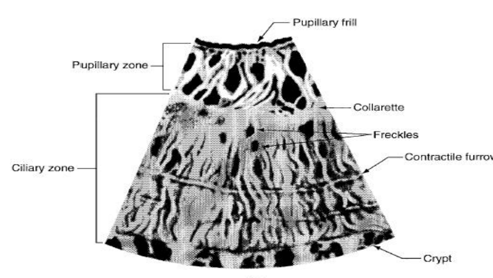


Fig. 1b

Fig.1 Anatomy of Human Iris a) Structure of Iris seen in transverse section b) Structure of Iris seen in frontal section.

III. IRIS RECOGNITION SYSTEM

A typical Iris recognition system involves two main modules.

A Image acquisition: Acquisition system captures sequence of images from a specially designed sensor. Since the iris is fairly small (1cm diameter) capturing iris images of high quality is one of the major challenges for practical applications. Much work has been done on iris image acquisition [13] [14][15]. More recent work can be found on website [16]. The following points are of particular concern. Firstly, the image, which is acquired, must have sufficient resolution and sharpness to support recognition. Secondly, it is important to have good contrast without restoring the level of illumination that annoys the subject. Thirdly, these images must be well framed (i.e. centred) without constraining the subject and finally artifacts in the acquired images (e.g. Specular reflections, optical aberrations etc.) should be removed. We have worked on image download from website [17].The image obtained from acquisition is shown in the Fig. 3

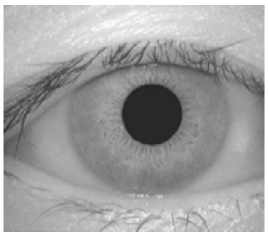


Fig. 3 Image acquired from acquisition system

B Iris Detection: This is the main component of any iris detection system and determines the systems performance. The iris detection method in this paper is divided into three steps viz. iris localization and centring, pattern matching and finally identification. The first stage solves the problem of how to choose a clear and well focused iris image. Without placing undue constraints on the human operator, image acquisition of the iris cannot be expected to yield an image containing only the iris. The standard image acquisition systems will capture the iris as a part of a larger image that also contains information surrounding the iris which is not of much use in iris detection [14]. Therefore before performing iris matching, it is important to isolate the iris and eliminate the surrounding structures like the pupil, the eyelashes etc. In particular it is necessary to localize that portion of the image derived from inside the limbus (the border between the sclera and the iris) and outside the pupil. The iris localization must be sensitive to a wide range of edge contrasts, robust to irregular borders and capable of dealing with variable occlusion. Having isolated the region that corresponds to the iris, the final task is to decide if this pattern matches a previously stored iris pattern.

IV. IRIS LOCALISATION

The first objective is to isolate the iris of the subject. A circular contour is formed of the desired diameter around the iris to eliminate the region that surrounds the iris. This circular image formed is binary having the inner area of value 1 and the outer area of value 0. One has to be careful regarding the diameter of the circular image, as it should encircle the entire iris. The diameter chosen should be common to all human iris images. This binary image when multiplied with the iris image leaves us with only the iris and most of the surrounding regions get eliminated. The circular contour around the iris is shown in Fig.4. The circular contour image is moved such that it is concentric with the pupil. The limbus as the pupilary boundary of the iris, are concentric about the pupilary center and hence this center needs to be determined [11],[12],[13]. We use simple point processing techniques viz. thresholding and grey level slicing to eliminate every feature other than the pupil

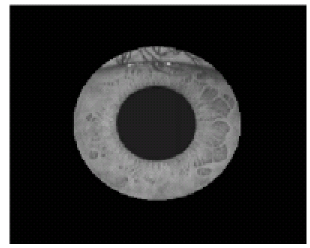


Fig. 4 Formation of a circular contour around the iris

This is done using a simple technique [24],[25],[26]. We find the row and the column having the maximum number of pixel. This corresponds to the centre. Once the centre is known, we shift the centre of the circular contour that we had generated to the centre of the pupil. This alignment is required as minor shifts occur due to offsets in the position of the eye along the cameras optical axis. The localized iris is now at the centre of the image frame. This is shown in the figure Fig.5. At this stage we also calculate the limbus and the pupil diameters.

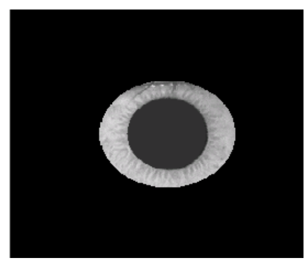


Fig. 5 Isolated iris at the centre of the frame

V. EIGEN IRISES

Once the iris is isolated and centered, we proceed with the Principal Component Analysis (PCA) [17] of the iris. The PCA is a statistical method under the broad title of factor analysis. Because PCA is a classical technique which can be applied in the linear domain, they are suitable in applications having linear models such signal processing, image processing, communications etc. [18].This paper uses 5 different images of a single iris taken at different instances of time [22]. Given below are the steps involved in computing the Eigen irises.

1. We compute the average of all 5 iris images $I_1, I_2, \ldots I_5$.

$$I_{avg}(x, y) = 1/5 \sum_{i=1}^{5} I_i(x, y) \quad (1)$$

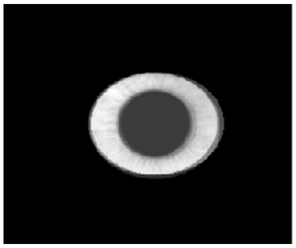


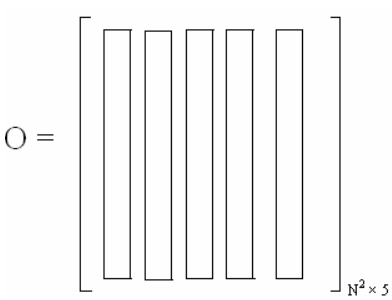
Fig. 6. Mean Image

2. We then compute the Zero mean images

$$I_z = I_i - I_{avg} \quad (2)$$

This gives us 5-Zero mean images

3. Each of these Zero mean Images are then converted into a one-dimensional column vector by placing each column one below the other. Assuming the original size of the iris image to be N×N, this stacking would give us 5 column vectors each of size $N^2 \times 1$. These are then arranged as a matrix of size $N^2 \times 5$



4. We now compute the Covariance matrix using the simple formula

$$C = [O^T \times O] \quad (3)$$

Since O^T is of size $5 \times N^2$ and O is of size $N^2 \times 5$, Covariance matrix, C, will be of size 5 × 5.

5. The covariance matrix is symmetrical; hence it is fairly easy to compute its eigenvectors [19].
Eigenvectors and eigenvalues are computed using the formulae

$$CV = \lambda V \quad \text{and} \quad (4)$$
$$[\, C - \lambda I \,]\, V = 0$$

Where λ's are the eigenvalues and V's are the eigenvectors. As stated earlier, a set of 5 images of the same iris, captured at different times, were taken. This gives us 5 eigenvectors (V_1, V_2,..,V_5).

6. We multiply each of the eigenvectors with O.

$$f_i = [O]\, V_i \quad (5)$$

Since O is of size $N^2 \times 5$ and Vi is of size 5 × 1, f_i would be a one-dimensional column vector of size $N^2 \times 1$.

7. We finally compute the *eigen-irises* by converting f_i into a 2-dimensinal image F_i. This can be achieved by reversing the steps given in step 3.

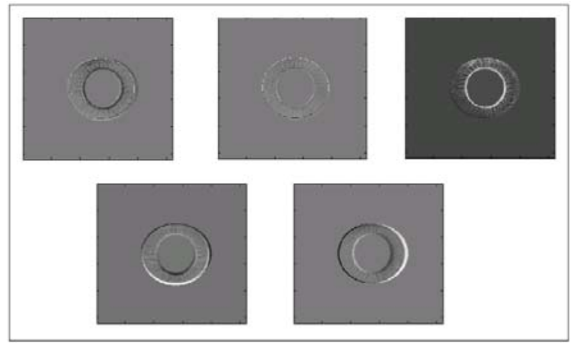


Fig. 7 Five eigen-irises

Once the eigen-irises have been computed, several types of decision can be made depending on the application.

VI. RECOGNITION

Recognition of a person is a process where it must be decided if the individual has already been seen,
A new image I_{new} is transformed into its eigen-iris components (projected into 'iris-space') by a simple operation,

$$w_k = V_k^T (I_{new} - I_{avg}) \quad (6)$$

Here k = 1,2,….5. The weights obtained from the equation are arranged to form a vector

$$\Omega^T = [w_1, w_2, w_3, w_4, w_5] \quad (7)$$

This vector describes the contribution of each eigen-iris in representing the new input iris image [20]. This vector can then be used in a standard pattern recognition algorithm
An iris class can be calculated by averaging the weight vectors for the images of one individual. The Euclidean distance of the weight vector of the new image from the iris class weight vector can be calculated using the Euclidean distance [21] as follows,

$$\varepsilon_k = \| \Omega - \Omega_k \| \quad (8)$$

Where, Ω_k is a vector describing the k^{th} iris class. The iris is classified as belonging to class k when the distance ε_k is below some threshold value $\theta\varepsilon$. Otherwise the face is classified as unknown.
The concept of eigen-irises for recognition can be used in conjunction with Multi-resolution analysis involving Laplacian of Gaussian operator [26] to design a robust iris recognition algorithm.

VII. CONCLUSION

The Principal Component Analysis is one of the most successful techniques used in image recognition and face recognition. A great deal of work has been done in face recognition using the PCA. In literature, eigen faces have been demonstrated to be very useful for face recognition. This is an attempt at using the same technique in identifying irises. The Principal Component Analysis reduces the dimensionality of the training set, leaving only those features that are critical for iris recognition.

Iris recognition is a fast developing art. It is a classic biometric application. The work carried out in the paper could also be used in the near future to detect some of the abnormalities in the iris.

VIII. REFERENCES

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IX. BIOGRAPHY

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