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A Novel Approach for Iris Recognition

Manisha M. Khaladkar, Sanjay R. Ganorkar

***Abstract*— The iris has been proposed as a reliable means of biometric identification. The importance of the iris as a unique identifier is predicated on the assumption that the iris is stable throughout a person's life. Also, the need for security systems going up, Iris recognition is emerging as one of the important methods of biometrics-based identification systems. Iris biometry has been proposed as a sound measure of personal identification. Iris biometry has been proposed as a sound measure of personal identification. This project basically explains comparison of the purposed algorithm with the existing algorithms for Iris recognition. In proposed method, image preprocessing is performed using Daugman's Integro-differential operator. The extracted iris part is then normalized using Daugman's rubber sheet model followed by extracting the iris portion of the eye image using Haar transform. Finally two Iris Codes are compared to find the Hamming Distance which is a fractional measure of the dissimilarity. The results obtained with this algorithm are of highest accuracy whereas the false acceptance ratio (FAR) and false rejection ratio (FRR) are lowest compared to existing algorithms.**

***Index Terms*—Image Segmentation, Hough transform, Gabor wavelet, Haar wavelet transform, hamming distance, Euclidian distance, Daugman's integro-differential operator**.

I. Introduction

A biometric system provides automatic recognition of an individual based on some sort of unique feature or characteristic possessed by the individual. Iris recognition, as an extremely reliable method for identity authentication, is playing a more and more important role in many mission-critical applications, such as assess control, national ID card, border crossing, welfare distribution, missing children identification, etc. The uniqueness of iris pattern comes from the richness of texture details in iris images, such as freckles, coronas, crypts, furrows, etc. It is commonly believed that it is impossible to find two persons with identical iris patterns, even they are twins. The randomly distributed and irregularly shaped microstructures of iris pattern make the human iris one of the most informative biometric traits. Although the human visual system can observe the distinguishing iris features effortlessly, the computational characterization and comparison of such far from a trivial task and has attracted much attention for the past decade.

***Manisha M. Khaladkar**, Department of ETC, Pune University Sinhgad College of Engineering., (e-mail: manisha226257@gmail.com). Pune, India, Mobile No 9860238902.*

***Sanjay R. Ganorkar**, Department of ETC, Pune University Sinhgad College of Engineering.,India, Mobile No., 9422514726 (e-mail: srgomom@rediffmail.com).*

II. Image Pre-processing

A. Segmentation

Initially eye images must be segmented to extract only the iris region by locating the inner (pupil) and outer boundaries of the iris. Occluding features must also be removed and the iris pattern normalised. Segmentation is important with only accurately segmented images suitable for proceeding to the later stages of iris recognition. Daugman [1] implements integro-differential operators to detect the limbic boundary followed by the pupil boundary. An alternative segmentation method, proposed by Wildes [5], implements an edge detection operator and the Hough transform. Masek's algorithm [8] implements Canny edge detection and a circular Hough transform to segment the iris. Further techniques have been developed employing the same approach but with slight variations [4, 7, 9-11]. In contrast Kennell et al [12] proposed a segmentation technique with simple binary thresholding and morphological transformations to detect the pupil. Mira and Mayer [13] also implement thresholding and morphological transformations to detect the iris boundaries. Here, we have done the segmentation with Daugman's integro-differential operator. Two databases, MMU and Bath are used for experimentation. The range of radius values to search for is set manually, depending on the database used. For the MMU and Bath database, values of the iris radius range from 70 to 140 pixels, while the pupil radius ranges from 20 to 50 pixels. To reduce the processing time of the image shown in figure 1a, only the region of interest is only taken for further processing by cropping image which is done by statistical calculations of the coordinates as shown in figure 1 b.

Daugman's Integro-differential operator

The integro-differential operator is defined as-

$$max_{(r,x_p,y_o)} \left| G_\sigma(r) * \frac{\partial}{\partial r} \oint_{r,x_p,y_o} \frac{I(x,y)}{2\pi r} ds \right| \quad (1)$$

where I(x,y) is the eye image, r is the radius to search for, Gσ(r) is a Gaussian smoothing function, and s is the contour of the circle given by (r, x0, y0). The operator searches for the circular path where there is maximum change in pixel values, by varying the radius and centre x and y position of the circular contour. Here in this experimentation, to segment the Iris using Daugman's integro-differential operator, first the original image is cropped to reduce the processing time as shown in figure 1 a) and b). The cropped image is convolved with Laplacian mask, (3*3) which makes the image smooth i.e. sharp edges are smoothed. Now, the threshold is applied to an image with which the reflections are removed. To

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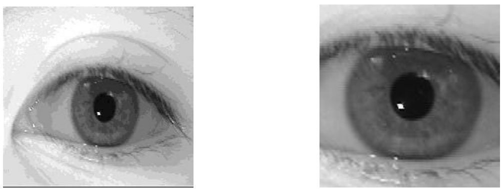
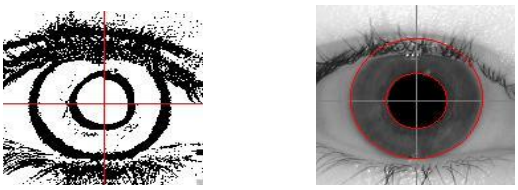
remove light intensity reflections present inside the pupil boundary, the non zero value are checked inside of inner circle by scanning the image vertically and horizontally as it gives wrong interpretation of centre co-ordinates. The thresholded image without with reflections is shown in figure 2a. Then, gradient of an image is calculated by taking every 5th pixel shift. The shift of pixel is taken with statistical calculations to get different intensity variations. The pixel shift reduces the noise. Now, to find exact center co-ordinates and radius, circles with all radii and centers are drawn. With this we got two circles which are detected by overlapping. These circles are nothing but pupil and iris boundary. Then scanning the image vertically and horizontally and finding maximum line in both directions we got two diameters. Half of these diameters are the radii and intersection of these is center. Average of these radii is taken as the radius for the circle. Same procedure is applied for inner and outer boundaries. The segmented iris is obtained as shown in figure 2 b). This image is then used for extracting features.



(a) (b)

Fig. 1 a) Original Image 1b) Cropped Image to reduce processing time



(a) (b)

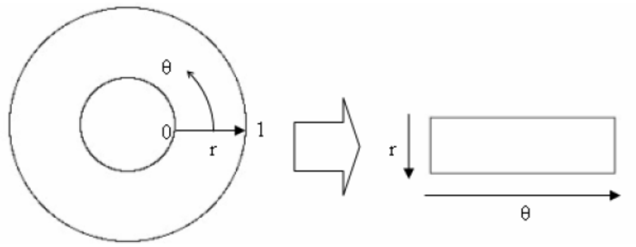
Fig. 2a) Thresholded image 2b) Segmented Iris using Daugman's IDO

III. NORMALIZATION

Once the iris region is successfully segmented from an eye image, the next stage is to transform the iris region so that it has fixed dimensions in order to allow comparisons. The dimensional inconsistencies between eye images are mainly due to the stretching of the iris caused by pupil dilation from varying levels of illumination. Other sources of inconsistency include, varying imaging distance, rotation of the camera, head tilt, and rotation of the eye within the eye socket. The normalization process will produce iris regions, which have the same constant dimensions, so that two photographs of the same iris under different conditions will have characteristic features at the same spatial location.

A. *Daugman's Rubber Sheet Model*

The homogenous rubber sheet model devised by Daugman [1] remaps each point within the iris region to a pair of polar coordinates (r,θ) where r is on the interval [0,1] and θ is angle [0,2π] as shown in figure 4a. The experimentation is done with constant radius and variable centre which draws lines around the circle. These lines are then converted into linear region. All the lines are having same length; as if any line is small padding is done to have equal length. The following figure shows the normalized iris image. The lower black portion is removal of eyelids, eyelashes and noise which is obtained with normalization.



(a)

(b)

Fig. 3 a) Daugman's Rubber sheet model
b) Normalization by Daugman's rubber sheet model

IV. FEATURE EXTRACTION

In order to provide accurate recognition of individuals, the most discriminating information present in an iris pattern must be extracted. Only the significant features of the iris must be encoded so that comparisons between templates can be made. Most iris recognition systems make use of a band pass decomposition of the iris image to create a biometric template. Different methods for feature extraction are used in this experimentation.

A. *Haar Wavelet*

In mathematics, the Haar wavelet is a sequence of rescaled "square-shaped" functions which together form a wavelet family or basis. Wavelet analysis is similar to Fourier analysis in that it allows a target function over an interval to be represented in terms of an orthonormal function basis. The Haar sequence is now recognized as the first known wavelet basis and extensively used as a teaching example. The Haar wavelet is as shown in figure 4.

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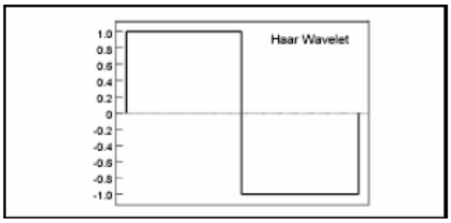

Fig. 4 The Haar wavelet

Here, to transform the image with Haar transform, we have used a 4*4 matrix as it reduces the number of calculations & gives more precise results. The matrix is moved on normalized image and pixel to pixel intensity variation is observed. The intensity variance pixel values are encoded for feature matching. The 4*4 Haar transform matrix used is as shown below. The figure 5 shows feature plot and Haar transformed image of the normalized image.

$$H_4 = \frac{1}{\sqrt{4}} \begin{bmatrix} 1 & 1 & 1 & 1 \\ 1 & 1 & -1 & -1 \\ \sqrt{2} & -\sqrt{2} & 0 & 0 \\ 0 & 0 & \sqrt{2} & -\sqrt{2} \end{bmatrix}$$

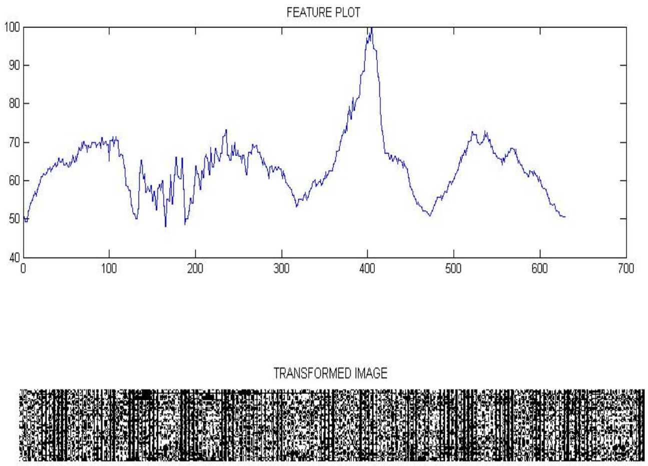

Fig. 5 Haar wavelet Output

V. MATCHING

The template that is generated in the feature encoding process will also need a corresponding matching metric, which gives a measure of similarity between two iris templates. This metric should give one range of values when comparing templates generated from the same eye, known as intra-class comparisons, and another range of values when comparing templates created from different irises, known as inter-class comparisons. These two cases should give distinct and separate values, so that a decision can be made with high confidence as to whether two templates are from the same iris, or from two different irises.

A. Hamming Distance

Daugman devised a test of statistical independence between two iris codes [2] and this has been implemented by many other authors including Masek [8] and Monro [4]. The Hamming Distance (HD) between the two irides to be compared is calculated. HD measures the number of identical bits between two binary bit patterns. A decision criterion based on the distribution of HDs of irides that are the same and the distribution of those that are different is determined. The overlap in these distributions determines the decision criterion. If the calculated HD between two images falls below the decision criterion, the irides are from the same person. If the calculated HD is higher, the irides are from different people.

For comparing two iris codes, a nearest-neighbor approach is taken, where the distance between two feature vectors is measured using the product-of-sum of individual subfeature Hamming distances (HD). This can be defined as follows:

$$HD = \left(\prod_{i=1}^{M} \frac{\sum_{j=1}^{N} (subFeature\ 1_{ij} \oplus subFeature\ 2_{ij})}{N} \right)^{1/M} \quad (2)$$

Here, we consider the iris code as a rectangular block of size M × N, M being the number of bits per sub feature and N the total number of sub features in a feature vector. Corresponding sub feature bits are XORed and the resultant N-length vector is summed and normalized by dividing by N. This is done for all M sub feature bits and the geometric mean of these M sums give the normalized HD lying in the range of 0 to 1. For a perfect match, where every bit from Feature 1 matches with every corresponding bit of Feature 2, all M sums are 0 and so is the HD, while, for a total opposite, where every bit from the first Feature is reversed in the second, MN/Ns are obtained with a final HD of 1.

TABLE 1 COMPARISON FOR DIFFERENT METHODS.

Algorithm	Segmentation	Extraction	Accuracy	FAR	FRR
Daugman	Daugman's Integro-differential Operator	2 D Gabor	99.9%	0.01	0.09
Masek	Hough transform	1 D Gabor	98%	0.01	1.98
Avila	Edge detection algorithms	Zero-crossings discrete dyadic wavelets	97.89	0.03	2.08
Tisse	Daugman's Integro-differential Operator	Gabor	89.37	1.84	8.79
Proposed	Daugman's Integro-differential Operator	Haar Transform	99.94%	0.005	0.01

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VI. CONCLUSION

The experimentation of Iris recognition system is tested on two databases, Bath and MMU. Initially, the preprocessing is carried with Daugman's Integro-differential operator and localized the iris region followed by the normalization carried out by implementing a version of Daugman's rubber sheet model which eliminates dimensional inconsistencies between iris regions and itself removes eyelid, eyelash and reflection areas. Then the features of the iris are encoded by convolving the normalized iris region with Haar wavelet and phase quantizing the output in order to produce a bit-wise biometric template. The Hamming distance is chosen as a matching metric, which is a measure of how many bits disagreed between two templates.

Comparing with existing algorithms, the proposed algorithm gives accuracy of 99.94% as shown in above table. Also, with number of experimentations, FAR and FRR are calculated for proposed algorithm and compared it with the existing algorithms as shown in above table. The proposed algorithm gives lowest FAR and FRR of 0.005 and 0.01 respectively.

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Manisha M. Khaladkar B.E. Electronics, M.E Digital systems (Pursuing) from Sinhgad college of Engg, Pune, M. S.India, has teaching experience of 8 years in Pune university M.S. India.

Sanjay R. Ganorkar Associate professor, Department of Engg., sinhgad college of Engg., Pune M.S. India, Pursuing his Phd in Image processing, has working experience of 20 years.