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The Role of Best bits in Iris for Efficient Person Authentication

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Abstract: ***Biometric person authentication techniques based on the pattern of the human iris is well suited to be applied to any access control system requiring a high level of security due to the desirable properties such as distinctiveness, non-invasiveness, and stability of iris patterns. In this paper, we have attempted for a different iris recognition method by deploying the best bits in an iris code. There are more number of inconsistent bits (fragile bits) near the pupil and the limbic boundary of the iris and can be masked. Only the most consistent bits (best bits) are selected and then matching is performed using the hamming distance method. The effectiveness of our proposed system is then verified with experimental results using a total of 750 iris images from CASIA iris image database. Also we have made a performance analysis, and found that the Best bit method gives good recognition rates, error rates for the above database and analyzed the Genuine Acceptance Rate (GAR), False Acceptance Rate (FAR) and False Rejection Rate (FAR). Even with this reduced feature set size, we are able to get good recognition rates in a lesser time compared to the other methods which uses all the bits in iris code.***

Keywords: Biometrics, Fragile bits, Hamming distance, Iris Recognition, Iris Code.

I. INTRODUCTION

A biometric system provides automatic recognition of an individual based on some sort of unique feature or characteristic possessed by the individual. Biometric systems have been developed based on fingerprints, facial features, voice, hand geometry, handwriting, the retina [19], and the one presented in this paper, the iris. An emerging biometric, iris recognition has received increasing attention in recent years due to its uniqueness, stability and non-invasiveness and will provide a promising solution to security in near future. The iris (Fig. 1) is an annular part between the pupil and the white sclera in the human eye and it has an extraordinary texture which is unique to each eye, as well as stable over an individual's lifetime. The average diameter of the iris is 12 mm, and the pupil size can vary from 10% to 80% of the iris diameter. The iris consists of a number of layers the lowest is the epithelium layer, which contains dense pigmentation cells. The stromal layer lies above the epithelium layer, and contains blood vessels, pigment cells and the two iris muscles. The density of stromal pigmentation determines the color of the iris. The externally visible surface of the multi-layered iris contains two zones, which often differ in color. An outer colliery zone and an inner papillary zone, and these two zones are divided by the collarets – which appears as a zigzag pattern.

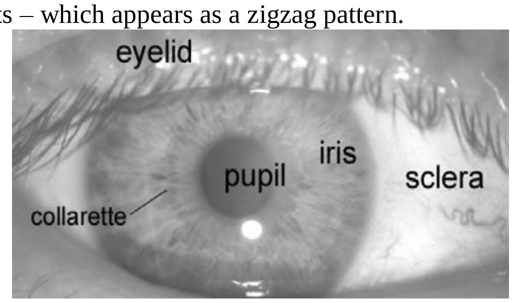

Fig 1 Side view of the human eye

For our developed approach of iris recognition, the input is an eye image, and the output is the iris template (a mathematical representation of the iris region) Although prototype systems had been proposed earlier, it was not until the early nineties that Cambridge researcher, John Daughman, implemented a working automated iris recognition system. Even though the Daugman's system is the most successful and most well known, many other systems have been developed. The most notable include the systems of Wildes et al., Boles and Boashash , Lim et al., and Noh et al. The Daugman's system is claimed to be able to perfectly identify an individual, given millions of possibilities. The prototype system by Wildes et al. also reports flawless performance with 520 iris images and the Lim et al. system attains a recognition rate of 98.4% with a database of around 6,000 eye images.
We have compared Daughman's system with the system which deployed the best bits in an iris code. Not all the bits in an iris code are equally useful. Some bits in an iris code are more consistent than other bits. The middle bands are consistent than the outer and inner bands.

II. IRIS RECOGNITION-FIRST METHOD

The system is composed of a number of sub-systems, which correspond to each stage of iris recognition. These stages are segmentation (localization) – locating the iris region in an eye image, normalization – creating a dimensionally consistent representation of the iris region, and feature encoding – creating a template containing only the most discriminating features of the iris. The input to the system will be an eye image, and the output will be an iris template (binary code), which will provide a mathematical representation of the iris region. Finally matching is performed to make a decision of accept or reject (Fig.2).

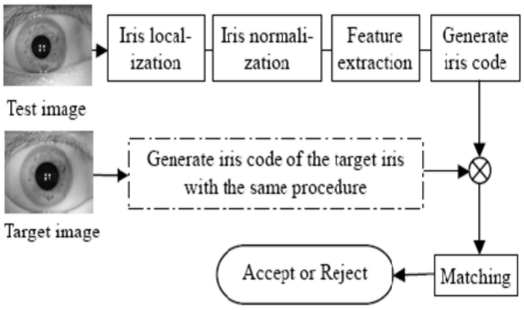

Fig.2 System framework of the iris recognition process

A. Iris pre-processing

An iris image needs to be pre-processed before using it for the recognition purpose as the unwanted data in the image such as eyelid, pupil and specular reflections should be excluded. Therefore, pre-processing is required to segment, normalize iris and exclude the artifacts [11]. The overview of the pre-processing flow is shown in (Fig. 3)

B. Iris segmentation

Segmentation is the first stage in iris pre-processing to isolate the actual iris region from a captured iris image. Canny edge detection is performed to create an edge map to generate gradients information. Circular Hough Transform which is employed by Wildes [18], is used to detecting the iris and pupil boundaries.

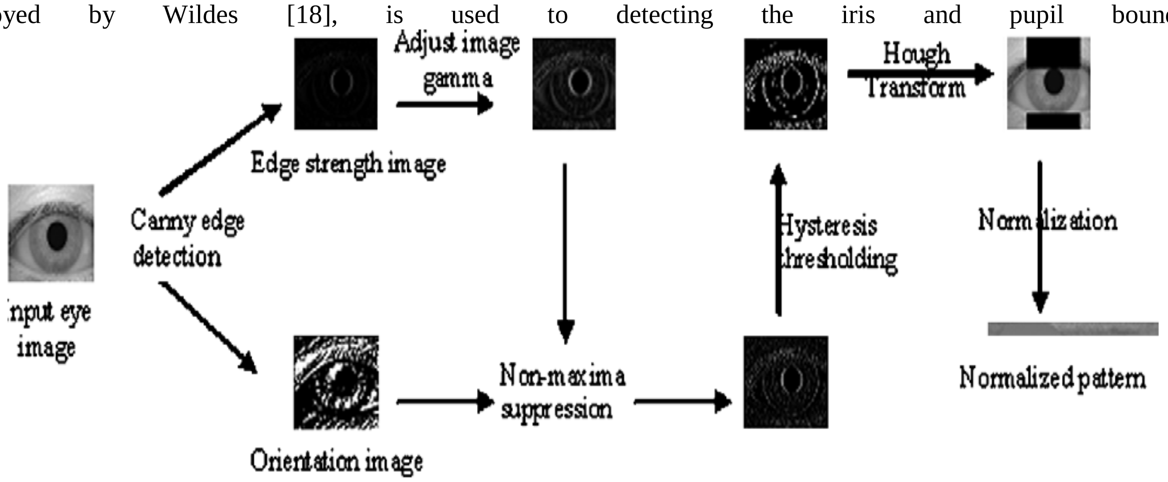

Fig.3.The flow diagram of Iris pre-processing

On the other hand, the eyelids and eyelashes can be solated by applying Linear Hough Transform. The overall method is very efficient and reliable as it managed to segment the iris region perfectly and isolate most occluding eyelashes occurring within the iris region. This was eliminated, using threshold, since reflection areas are characterized by high pixel values close to 255. For the eyelid, eyelash, and reflection detection process, the coordinates of any of these noise areas are marked using the MATLAB NaN type, so that intensity values at these points are not misrepresented as iris region data.

C. Iris normalization

Normalization is a process of transforming the segmented iris region into fixed dimension. The dimensional inconsistencies between eye images are mainly due to the stretching of the iris caused by pupil dilation from varying levels of illumination. The purpose of normalization is to compensate the iris deformation, which is caused by illumination variations. Such elastic deformation in iris texture will affect the result of iris matching. The iris regions with same dimensions will be used for comparisons.

For this normalization process, Daugman's rubber sheet model has been applied (Fig.4).

$$I(x(r,\theta), y(r,\theta)) \rightarrow I(r,\theta)$$

With

$$x(r,\theta)=(1-r)x_p(\theta)+rx_1(\theta) \quad (1)$$
$$y(r,\theta)=(1-r)y_p(\theta)+yx_1(\theta)$$

Another point of note is that mainly due to the stretching of the iris caused by pupil dilation from varying levels of illumination. The purpose of normalization is to compensate the iris deformation, which is caused by illumination variations. The pupil region is not always concentric within the iris region, and is usually slightly nasal. Daugman's rubber sheet model remaps the annular iris image $I(x, y)$ from raw Cartesian coordinates (x, y) to a dimensionless pseudo-polar coordinate system (r, θ)[17].

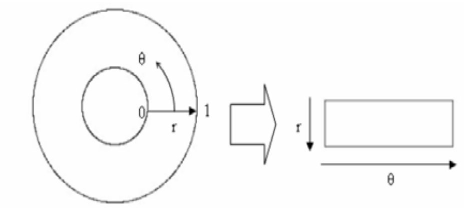

Fig.4 Daugman's rubber sheet model

The rubber sheet model takes into account pupil dilation and size inconsistencies in order to produce a normalized representation with constant dimensions. In this way the iris region is modeled as a flexible rubber sheet anchored at the iris boundary with the pupil centre as the reference point. The normalization produces a 2D array with horizontal dimensions of angular resolution and vertical dimensions of radial resolution. In this paper, a template of dimension 20 X 240 is produced, where 20 is the radial resolution and 240 is the angular resolution. The normalization process proved to be successful and some results are shown in (Fig.5)

D. Normalized iris enhancement

The normalized pattern is enhanced for improving the contrast of the image. For this enhancement histogram equalization method is used. This method usually increases the global contrast of many images, especially when the usable data of the image is represented by close contrast values. Through this adjustment, the intensities can be better distributed on the histogram. This allows for areas of lower local contrast to gain a higher contrast without affecting the global contrast. Histogram equalization accomplishes this by effectively spreading out the most frequent intensity values. The iris pattern before and after enhancement is shown in (Fig.6).After the equalization all the pixel intensity values are equally distributed throughout the image.

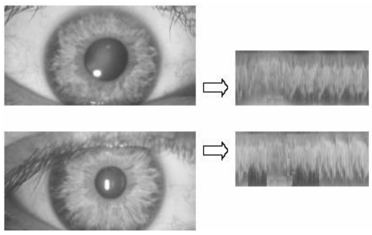

Fig.5 Normalization process for two same iris Images

a)

b)

Fig. 6 a) Normalized image b) Enhanced image after histogram equalization.

III. FEATURE ENCODING

Feature encoding is an important process in iris recognition. Its objective is to extract the underlying information in an iris pattern, to be encoded for the matching purposes. The iris feature is generated by convolving the normalized iris pattern with 1D Log-Gabor filters. A disadvantage of the Gabor filter is that the even symmetric filter will have a DC component whenever the bandwidth is larger than one octave [20]. To overcome this disadvantage, a type of Gabor Filter known as Log-Gabor Filter, which is Gaussian on a logarithmic scale, can be used to produce zero DC components for any bandwidth.

$$g(f)=\exp(-\log(f/f_0))^2/2(\log(\sigma/f_0)) \quad (2)$$

Where f_0 represents the centre frequency, and σ gives the bandwidth of the filter.

By applying 1D Log- Gabor Filters, 2D normalized pattern is divided into a number of 1D signals, and these 1D signals are convolved with 1D Gabor wavelets. The rows of the 2D normalized pattern are taken as the1D signal; each row corresponds to a circular ring on the iris region. The angular direction is taken rather than the radial one, which corresponds to columns of the normalized pattern, since maximum independence occurs in the angular direction. The filter is constructed by calculating the radial filter component such as center frequency of filter and normalized radius from center of frequency plane. resultant complex features are phased quantized and are then encoded into binary iris templates [3].

IV. MATCHING

Matching is a process to determine whether two iris templates are from the same individual. For matching, the Hamming distance was chosen as a metric for recognition, since bit-wise comparisons were necessary. The Hamming distance algorithm employed also incorporates noise masking, so that only significant bits are used in calculating the Hamming distance between two iris templates.

HD=||(CODE C XOR CODE D)∩ (MASK C ∩MASK D)|| / ||(MASK C ∩ MASK D)|| (3)

- HD is the Hamming distance as a ratio
- C and D are two normalized iris
- code C and code D are respectively the bit-code of C and D
- mask C and mask D are respectively the mask of noise of C and D

Now when taking the Hamming distance, only those bits in the iris pattern that corresponds to '0' bits in noise masks of both iris patterns will be used in the calculation. The Hamming distance will be calculated using only the bits generated from the true iris region. Although, in theory, two iris templates generated from the same iris will have a Hamming distance of 0.0, in practice this will not occur. Normalization is not perfect, and also there will be some noise that goes undetected, so some variation will be present when comparing two intra class iris templates. The hamming distance calculation between two templates is shown in (Fig.7)

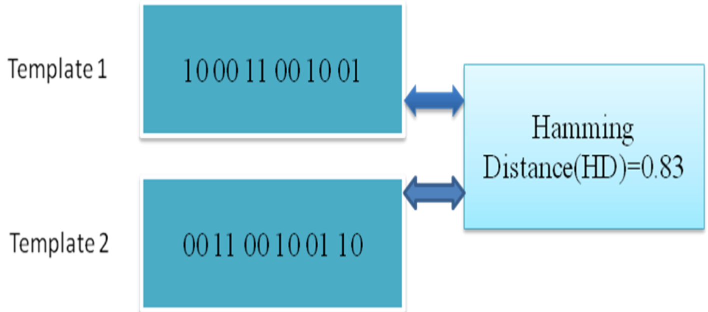

Fig.7 Hamming distance calculation

V. IRIS RECOGNITION-BEST BIT METHOD

The output of the feature encoding process is the binary iris template. In that iris code not all the bits are equally useful. Some bits are more consistent than other bits. The bits in the middle rows of the iris individually unique signal is found in the inner rings of the iris and that as one traverse to the limbic boundary of the iris, the pattern becomes less defined and ultimately less useful in determining identity. So towards both the pupil and the limbic boundary the bits are more fragile.

Due to this the percentages of fragile bits in each row of the iris code, Rows in the middle of the iris code (rows 5 through 12) are the most consistent bits. [Fig.8]

We have taken those most consistent bits and perform feature encoding process. The output which is the binary template is used for matching between the templates. The hamming distance between those templates which have deployed the best bits is reduced. The minimum value for hamming distance is obtained. We have compared the Daughman's method with this best bit method and the experimental results are shown.

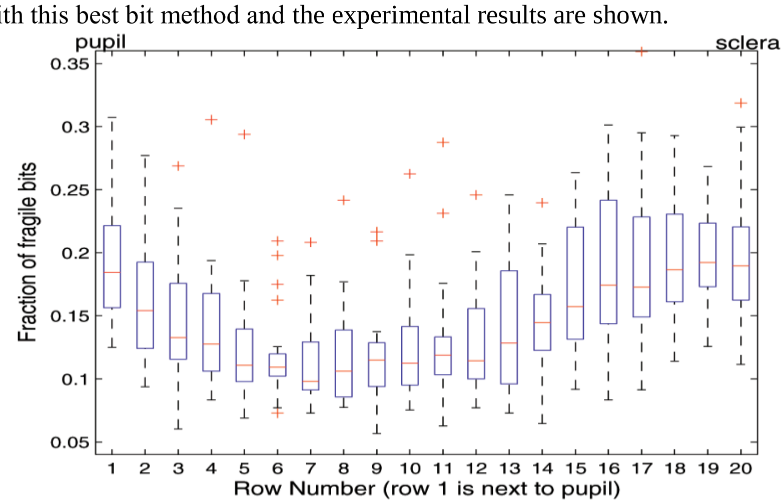

Fig.8 The percent of fragile bits in each row of the iris code. Rows in the middle of the iris code (rows 5 through 12) are the most consistent

VI. EXPERIMENTAL RESULTS AND DISCUSSIONS

To evaluate the performance of the both the methods we use "CASIA"[16] iris image database(version 3) created by National Laboratory of pattern recognition, Institute of Automation, Chinese Academy of Science that consists of more than 700 subjects. From this, 150 different persons i.e. 5 images for each person are taken. The experiments are performed in Matlab 7.0. GAR (Genuine Acceptance Rate), FAR (False Acceptance Rate) and FRR (False Rejection Rate) are calculated to evaluate the performance of the system. The database is tested for different threshold values to calculate the GAR, FAR and FRR. Table 1 and Table 2 presents the GAR, FAR, FRR at different thresholds for both the methods.

Table1. GAR, FAR and FRR rates for different threshold values for first method

Threshold	GAR	FAR	FRR
0.06	10.75%	0%	89.30%
0.08	55%	0%	45%
0.10	89.30%	0%	10.72%
0.12	100%	4.44%	0%
0.14	100%	22.22%	0%
0.16	100%	80.75%	0%
0.18	100%	100%	0%

To get the GAR, each person's extracted features are being compared with other image instances of the same person, as there are 5 images for each person in the database. In all of the comparisons if match score is less than the fixed threshold then it implies that a genuine person is not being accepted i.e. false rejection. By this way we get FRR.To get the FAR each person features are being compared with other 149 persons features, as there are 150 persons in the database. In any of the comparison if match score is more than the fixed threshold then it implies that a false person is being accepted. All such comparisons are made on the database to compute GAR, FAR and FRR at a fixed threshold. Experiment is repeated by fixing threshold to different thresholds.

Table2. GAR, FAR and FRR rates for different threshold values for second method

Threshold	GAR	FAR	FRR
0.20	8%	0%	92%
0.25	32%	0%	68%
0.27	54%	0%	46%
0.30	74%	0%	26%
0.35	96%	0%	4%
0.37	100%	0%	0%
0.40	100%	0%	0%
0.45	100%	20%	0%
0.47	100%	64%	0%
0.50	100%	100%	0%

Fig 9 Inter and intra class variations for I method

Fig 10 Inter and intra class variations for II Method

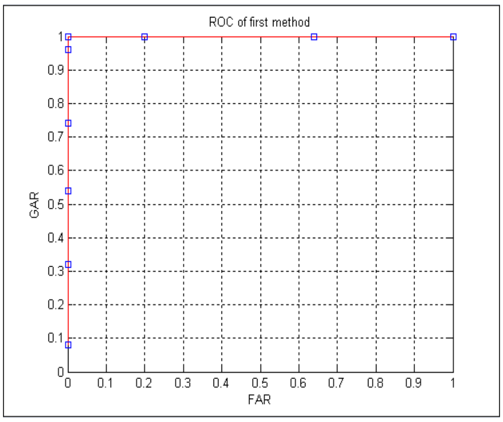

Fig 11 ROC curve between FAR & GAR for I method

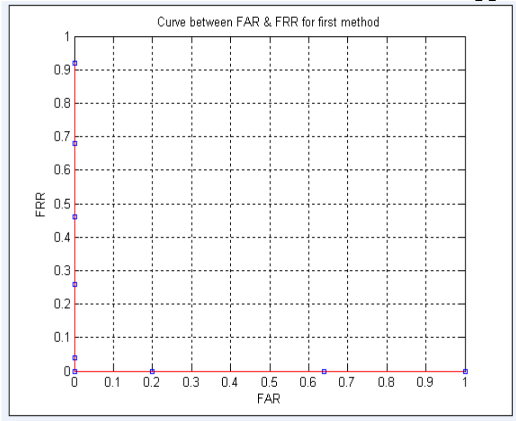

Fig 12 ROC curve between FAR &FRR for II method

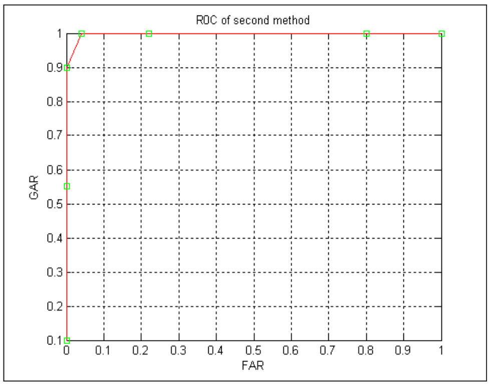

Fig 13 ROC curve between FAR & GAR for I method

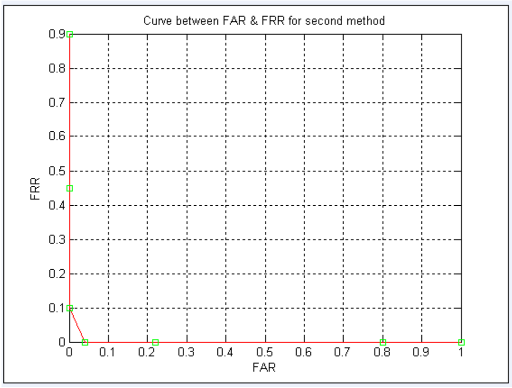

Fig 14 ROC curve between FAR &FRR for II method

VII. CONCLUSION AND FUTURE WORK

We have implemented a different iris recognition method by deploying the best bits in an iris code. This method involves iris Segmentation, Normalization, Feature encoding and masking more number of inconsistent bits (fragile bits) near the pupil and the limbic boundary of the iris and then the most consistent bits (best bits) are selected and then matching is performed using the hamming distance method. We have made a performance analysis, and found that the Best bit method gives good recognition rates, error rates for the above database and analyzed the Genuine Acceptance Rate (GAR), False Acceptance Rate (FAR) and False Rejection Rate (FRR) and compared their performances using the CASIA iris image database. As a future work we will address the practical issues of the latency for recognition and the performance can also be verified for multimodal biometrics by using noninvertible transformations.

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