

Iris Recognition System using 2D Log-Gabor Filter

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Abstract – Iris recognition is critical stage for whole iris recognition process for personal identification. Iris segmentation is very important for iris recognition system. If the iris regions were not correctly segmented there would possibly exist four kinds of noises in segmented iris regions: eyelashes, eyelids, reflections and pupil, which will result in poor recognition performances. In this paper, we presented an iris recognition algorithm based on 2D Log-Gabor filters to encode the unique pattern of the iris into a bit-wise biometric template. The Hamming distance was employed for classification of iris templates, and two templates were found to match if a test of statistical independence was failed. Therefore, iris recognition is shown to be a reliable and accurate biometric technology. The proposed decision strategy uses these features to authenticate an individual's identity while maintaining a low false rejection rate. The algorithm was tested on CASIA iris image database and found to perform better than existing approaches with an overall accuracy of 99.96%.

Keywords – automatic segmentation, biometric identification, iris recognition, pattern recognition MATLAB 7.8.0 (2009a).

I. INTRODUCTION

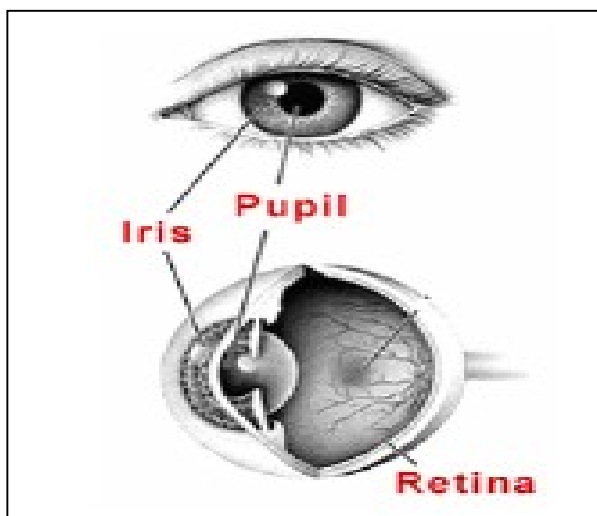


Fig. 1 : Human Eye

The iris region is as shown in Figure1, can be approximated by two circles, one for the iris/sclera boundary and another for the iris/pupil boundary. The eyelids and eyelashes normally occlude the upper and lower parts of the iris region. Also, specular reflections can occur within the iris region corrupting the iris pattern. A technique is required to isolate and exclude these artifacts as well as locating the circular iris region.

The iris is an externally visible, yet protected organ whose unique epigenetic pattern remains stable throughout adult life. These characteristics make it very attractive for use as a biometric for identifying individuals. Image processing techniques can be employed to extract the unique iris pattern from a digitized image of the eye, and encode it into a biometric template, which can be stored in a database. This biometric template contains an objective mathematical representation of the unique information stored in the iris, and allows comparisons to be made between templates. When a subject wishes to be identified by iris recognition system, their eye is first photographed, and then a template created for their iris region. This template is then compared with the other templates stored in a database until either a matching template is found and the subject is identified, or no match is found and the subject remains unidentified.

Although prototype systems had been proposed earlier, it was not until the early nineties that Cambridge researcher, John Daugman, implemented a working automated iris recognition system [1][2]. The Daugman system is patented [5] and the rights are now owned by the company Iridian Technologies. Even though the Daugman 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. [7], [3].

The Daugman system has been tested under numerous studies, all reporting a zero failure rate. The Daugman 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 [7], and the Lim et al. system attains a recognition rate of 98.4%

with a database of around 6,000 eye images. Compared with other biometric technologies, such as face, speech and finger recognition, iris recognition can easily be considered as the most reliable form of biometric technology [1]. However, there have been no independent trials of the technology, and source code for systems is not available. Also, there is a lack of publicly available datasets for testing and research, and the test results published have usually been produced using carefully imaged irises under favorable conditions.

*“Nothing to carry,
Nothing to remember.....”*

II. IRIS VERIFICATION

Firstly, an edge map is generated by calculating the first derivatives of intensity values in an eye image and then thresholding the result. From the edge map, votes are cast in Hough space for the parameters of circles passing through each edge point. These parameters are the centre coordinates x_c and y_c the radius which are able to define any circle according to the equation,

$$x^2_c + y^2_c - r^2_c = 0 \quad (1)$$

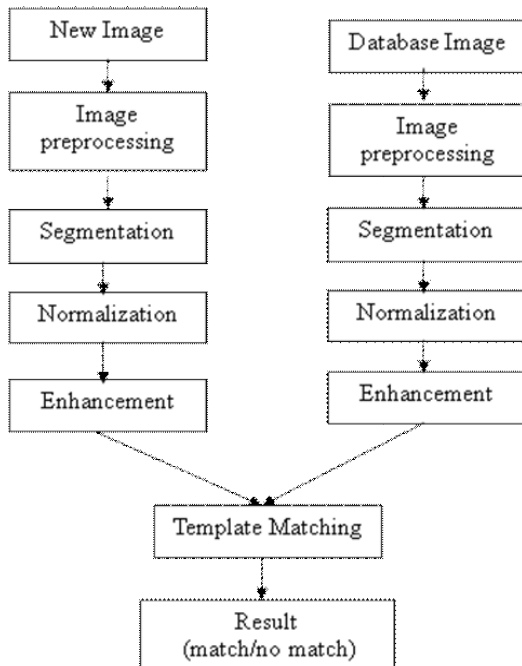


Fig. 2 : Iris Image Processing steps

A. Circle Detection & Normalization

A maximum point in the Hough space will correspond to the radius and centre coordinates of the circle best defined by the edge points. Wildes [3] also make use of the parabolic Hough transform to detect the eyelids approximating the upper and lower eyelids. In performing the preceding edge detection step, Wildes et al. bias the derivatives in the horizontal direction for detecting the eyelids, and in the vertical direction for

detecting the outer circular boundary of the iris. A normalization process is implemented to compensate for size variations due to the possible changes in the camera-to-face distance and to facilitate the feature extraction process by transforming the iris area represented by polar coordinate system into Cartesian coordinate system. The formula of the iris region from Cartesian coordinates to the normalized non-concentric polar representation is modeled as:

$$I(x(r\theta), y(r, \theta)) \rightarrow I(r, \theta) \quad (2)$$

$$x(r, \theta) = (1 - r)x_p(\theta) + rx_i(\theta) \quad (3)$$

$$y(r, \theta) = (1 - r)y_p(\theta) + ry_i(\theta) \quad (4)$$

Where $I(x, y)$ is the iris region image, (x, y) are the original Cartesian coordinates, (r, θ) are the corresponding normalized polar coordinates, and x_p, y_p and x_i, y_i are the coordinates of pupil and iris boundary along direction θ . The image of polar coordinates is shown below.

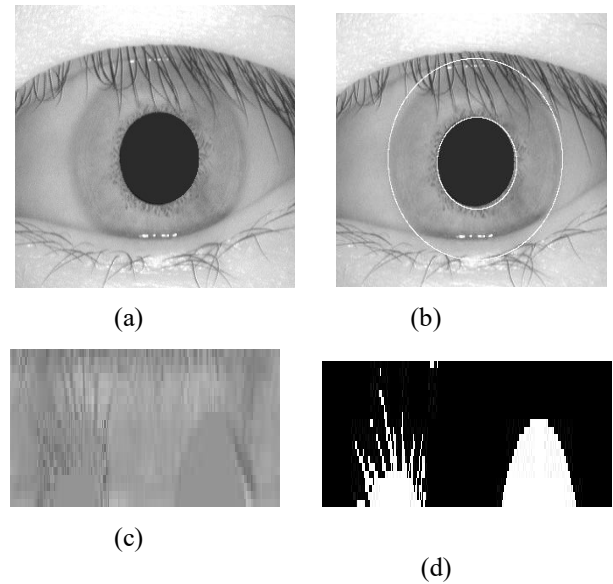


Fig. 3 :

(a) Eye Image (b) Inner and Outer Boundaries
(c) Iris in polar coordinates (d) corresponding Polar noise

B. Template Generation

In this section describes the extraction of textural features from the preprocessed image using log Gabor filter. The template generated by encoding the textural features is called the iris template. We propose the use of 2D log Gabor filter for iris texture template polar coordinates but unlike the frequency dependence on a linear graduation the dependency is realized by logarithmic frequency scale. Therefore, the functional form of 2D log-Gabor filter is given by,

$$G(u, v) = \exp\left\{\frac{-[\log(u_1 / u_0)]^2}{2[\log(k / u_0)]^2}\right\} \exp\left\{\frac{-v_1^2}{2\sigma_v^2}\right\} \quad (5)$$

Where $u_1 = u \cos(\theta) + v \sin(\theta)$, $v_1 = -u \sin(\theta) + v \cos(\theta)$, θ is the orientation of 2D Log-Gabor filter, u_0 is the center frequency, k determines the bandwidth of the filter in the u_1 direction, & σ_v determines the bandwidth of the filter in the v_1 direction. To generate an iris template from the proposed 2D log polar Gabor filter, the 2D normalized pattern, i.e. polar iris image, is decomposed into a number of 2D signals where each row corresponds to a circular ring on the iris region. The angular direction is used rather than the radial one, which corresponds to columns of the normalized pattern because maximum independence occurs in the angular direction. These 2D signals are then convolved with the 2D log Gabor filter in frequency domain. The complex valued output signals are encoded as presented in to generate the iris template. The iris template is a bitwise template containing a number of bits of information, and a noise mask which corresponds to noisy areas within the iris pattern. Figure

C. Template Matching

With the help of Hamming distance we measure the how many bits are the same between two bit patterns. Hamming distance of two bit patterns, a decision can be made as to whether the two patterns were generated from different irises or from the same one. For the two masked binary templates A & B, HD can be calculated by

$$HD = \frac{\sum [(codeA \otimes codeB) \cap (maskA \cap maskB)]}{\sum (maskA \cap maskB)} \quad (6)$$

Where, $\otimes$ denotes the Boolean Exclusive-OR operator (XOR), $maskA$ and $maskB$ denotes two iris matching masks, respectively, “0” for non-iris regions, and “1” for the iris regions, $\cap$ denotes the AND operator. The predefined threshold masks the decision whether two irises are from the same person. In order to account for rotational inconsistencies, when the Hamming distance of two templates is calculated, one template is shifted left and right bit-wise and a number of Hamming distance values are calculated from successive shifts. The shifting process for one shift is illustrated in figure4.

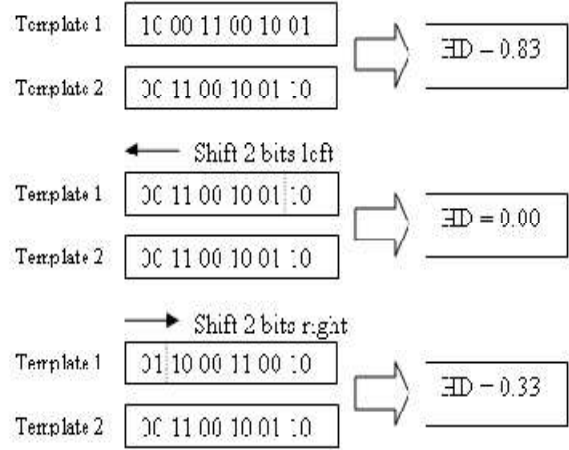
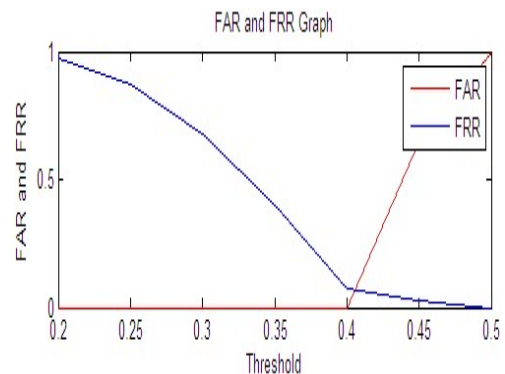


Fig. 4 : Shifting Process

In the shifting process, one shift is defined as one shift left, and one shift right of a reference template. In this example one filter is used to encode the templates, so only two bits are moved during a shift. The lowest Hamming distance, in this case zero, is used since this corresponds to the best match between the two templates.

III. EXPERIMENTAL RESULTS

The proposed methods of algorithm are tested on CASIA iris database. Experimented result shows that the verification performance of the proposed iris recognition algorithm is evaluated assuming that there is 0% false enrollment rate. Figure shows the intra-class and inter-class distance distribution plot of Hamming Distance calculated by the proposed 2D log Gabor filter. The accuracy (Accuracy = $100 - (FAR + FRR) / 2$) of the iris verification system is 99.96%, with zero false acceptance rate. This shows that the proposed decision algorithm reduces the false rejection rate. Figure shows that by increasing the number of training templates the FRR decreases and after 10 training samples it becomes approximately constant. Thus using three templates in the database we are able to predict the behavior of intra-class distribution more accurately and therefore work better than single-template.



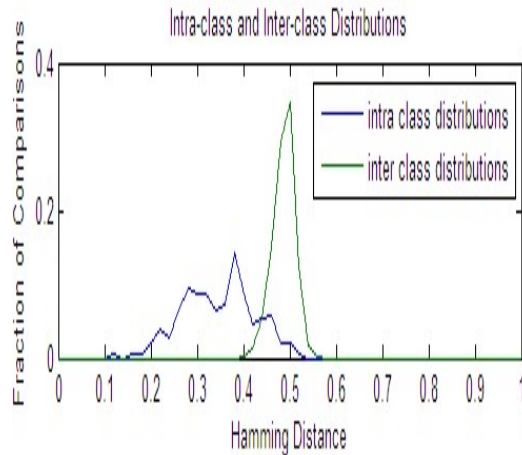


Fig. 5:

(a) FAR & FRR Plot using 2D log-Gabor filter

(b) Inter-class & Inter-class distribution plot using 2D log-Gabor filter

In this paper we also compared the accuracy and the false rejection rates of the proposed algorithm with the algorithms proposed by Daugman [1], Li *et. Al.* [8], and Tan [9]. Table 1 shows the verification accuracy of the algorithms. The experimental results show that the proposed algorithm is much better than the algorithms proposed in [8] and [9] and is comparable with Daugman's algorithm [1].

TABLE I

Performance comparison of Algorithms

ALGORITHM	FAR	FRR	ACCURACY
Daugman [1]	0.00	0.13	99.94
Li M. <i>et. al</i> [8]	0.00	0.87	99.57
Tan <i>et. Al</i> [9]	0.00	1.03	99.49
Proposed system	0.00	0.0750	99.96

IV. CONCLUSION

This paper presented the iris recognition system for textural features of an iris image to reduce the false rejection rates. The Hamming distance is employed for classification of iris templates, and two templates were found to match if a test of statistical independence was failed. The proposed 2D log-Gabor Filter is applied on a

transformed polar iris image to extract textural features. A decision strategy is proposed to verify the authenticity of an individual. Experimental results show that the proposed system is used to reduce the false rejection cases with zero false acceptances rate. Also, the proposed system is compared with the existing algorithms.

V. REFERENCES

- [1] J. G. Daugman, "High Confidence Visual Recognition of Persons by a Test of Statistical Independence", IEEE Transactions on Pattern Analysis and Machine Intelligence Vol.15, No. 11, pp. 1148–1161,1993.
- [2] Daugman, "Recognizing People by their Iris Pattern", Information Security Technical Report, Vol. 13 (1) pp 33-39, 1998.
- [3] Wildes P. "Iris Recognition: An Emerging Biometric Technology", Proceedings of IEEE, Vol. 85 (9) pp 1348-1363, 1997.
- [4] Masek Libor, "Recognition of Human Iris Patterns for Biometric Identification", School of Computer Science and Software Engineering, The University of Western Australia. 2003
- [5] Zhengping HU, Wang Chengfu, YU Lina, "Iris Location Improved Randomized Hough Transform" Yi Qi Yi Biao Xue Bao, Vol. 24 (5) pp 477-479, 2003.
- [6] Ali Ajdari, Karim Faez. "Fast Circle Detection Using Gradient Vectors", Proceedings of 7nd Digital Image Computing: Techniques and Applications, Vol. 1 pp 879-887, 2003.
- [7] Chen Tehchuan Chung Kouliang, "An Efficient Randomized Algorithm for Detecting Circles", Computer Vision and Image Understandings.
- [8] L. Ma, T. Tan, Y. Wang and D. Zhang, "Efficient Iris Recognition by Characterizing Key Local Variations", IEEE Transactions on Image Processing, Vol. 13, No. 6, 2004, pp. 739-750.
- [9] T. Tan, L. Ma, Y. Wang and D. Zhang, "Personal Identification based on Iris Texture Analysis", IEEE Transactions on Pattern Analysis and Machine Intelligence , Vol. 25, No. 12, 2003, pp. 1519-1533.

