IJCSC International Journal of Computer Science and Communication Vol. 2, No. 1, January-June 2011, pp. 239-242

COMPARATIVE ANALYSIS OF ROBUST IRIS RECOGNITION SYSTEM USING LOG GABOR WAVELET AND LAPLACIAN OF GAUSSIAN FILTER

Bhawna Chouhan[1] and Shailja Shukla[2]

[1]M.E. VI SEM, JEC, Jabalpur, *E-mail: bhawana241@gmail.com*

[2]JEC, Jabalpur, *E-mail: shailja.shukla@indiatimes.com*

ABSTRACT

A biometric system provides automatic identification of an individual based on a unique feature or characteristic possessed by the individual. Iris recognition is regarded as the most reliable and accurate biometric identification system available. Most commercial iris recognition systems use patented algorithms developed by Daugman, and these algorithms are able to produce perfect recognition rates. Especially it focuses on image segmentation and feature extraction by using Log Gabor wavelet and Laplacian of Gaussian filter for iris recognition process. The performance of iris recognition system highly depends on edge detection. The Canny Edge Detector is one of the most commonly used image processing tools, detecting edges in a very robust manner. This paper presents a straightforward approach for segmenting the iris patterns. The used method determines an automated global threshold and the pupil center. Experiments are performed using iris images obtained from CASIA database (Institute of Automation, Chinese Academy of Sciences) and Matlab application for its easy and efficient tools in image manipulation.

Keywords: Iris recognition; image processing, canny edge detection, log Gabor wavelet, Laplacian of Gaussian filter.

1. INTRODUCTION

Biometrics involves recognizing individuals based on the features derived from their Physiological and behavioral characteristics. Biometric systems provide reliable recognition schemes to determine or confirm the individual identity. A higher degree of confidence can be achieved by using unique physical or behavioral characteristics to identify a person; this is biometrics. A physiological characteristic is relatively stable physical characteristics, such as fingerprint, iris pattern, facial feature, hand silhouette, etc. This kind of measurement is basically unchanging and unalterable without significant duress. Applications of these systems include computer systems security, *e*-banking, credit card, access to buildings in a secure way. Here the person or object itself is a password [1] [2]. Once the preprocessing step is achieved, it is necessary to detect the images. After that, we can extract the texture of the iris [4]. Finally, we compare the coded image with the already coded iris in order to find a match an impostor. These procedures can be viewed as depicted in Fig.1.

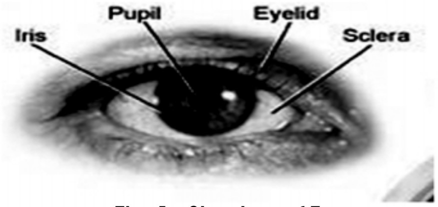

Fig. 1: Structure of Eye

A sample iris image is shown in Fig 1. Since it has a Circular shape when the iris is orthogonal to the sensor, iris recognition algorithms typically convert the pixels of the iris to polar coordinates for further processing. An important part of this type of algorithm is to determine which pixels are actually on the iris, effectively removing those pixels that represent the pupil, eyelids and eyelashes, as well as those pixels that are the result of reflections. Daugman [5] is the first one to give an algorithm for iris recognition. The algorithm gives the accuracy of more than 99.9%. Also the time required for iris identification is less than one second.

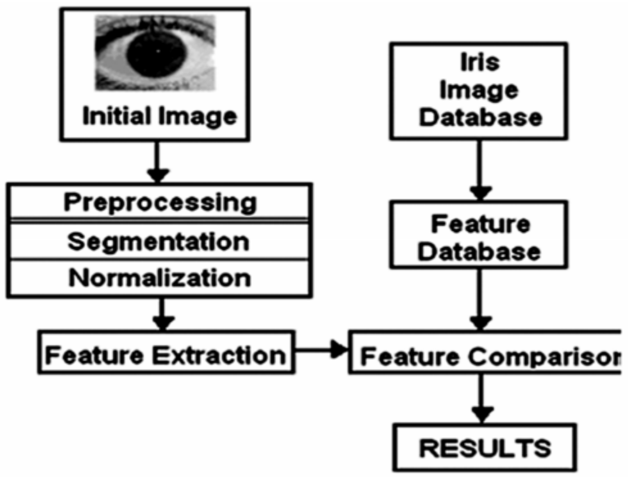

Fig. 2: Iris Identification System

Human iris identification process is basically divided into four steps,

2. LOCALIZATION A CANNY EDGE DETECTION

The Canny Edge Detector is one of the most commonly used image processing tools, detecting edges in a very robust manner. The Canny edge detection algorithm is known to many as the optimal edge detector. The second criterion is that the edge points be well localized. In other words, the distance between the edge pixels as found by the detector and the actual edge is to be at a minimum. A third criterion is to have only one response to a single edge. The algorithm runs in 5 separate steps:

Then compute the gradient magnitude and the angle of magnitude:

$$D = \sqrt{D_x^2(x, y) + D_y^2(x, y)}$$

$$\theta = \arctan\left(\frac{D_x(x, y)}{D_y(x, y)}\right) \quad (1)$$

B. HOUGH TRANSFORM

The HOUGH Transform is considered as a very powerful tool in edge linking for line extraction [11]. Its main advantages are its Insensitivity to noise and its capability to extract lines even in areas with pixel absence (pixel gaps) [6]. The Standard HOUGH Transform (SHT) proposed by Duda and Hart (Duda and Hart, 1972) [8] [9] is widely applied for line extraction in natural scenes, while some of its modifications have been adjusted for geologic lineament extraction purposes. The circle is simpler to represent in parameter space, compared to the line, since the parameter of the circle can be directly transfer to the parameter space. The equation of the circle is:

$$(x - a)^2 + (y - b)^2 = r^2 \quad (2)$$

As it can be seen the circle to get three parameter r, a and b, where a and b are the centre of the circle in the direction x and y respectively and r is the radius. Then we have a n dimensional parameter space (three dimensional space for a circle) [10]. This model has three parameters: two parameters for the centre of the circle and one parameter for the radius of the circle. For ellipses and other parametric objects the algorithm is quite similar, but the computation complexity (dimension of the Hough space) increases with the number of the variables.

3. NORMALIZATION

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 [7]. We will be using Daugman's Rubber Sheet Model for normalization.

A. Daugman's Rubber Sheet Model

Daugman suggested normal Cartesian to polar transformation that maps each pixel in the iris area into a pair of polar coordinates (r, θ), where r and θ are on the intervals of [0 1] and [0 2π] [2]. This unwrapping can be formulated as

$I(x(r, \theta), y(r, \theta))\ I(r, \theta)$ Such that

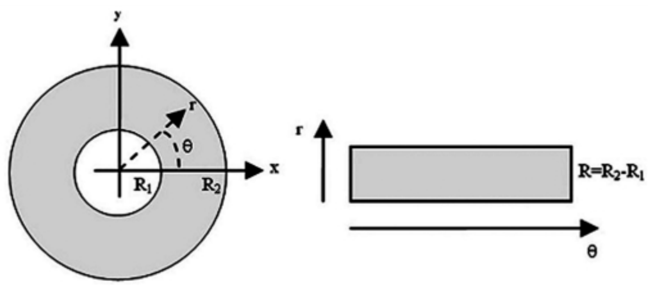

Fig. 3: Daughman's Rubber Sheet Model

4. FEATURE EXTRACTION

A. Log Gabor Wavelet

The iris has an interesting structure and presents plentiful texture information. So, it is attractive to search representation methods which can capture local crucial information in an iris [12]. For example, distinguishing structures range from the overall shape of the iris to the distribution of tiny crypts and detailed texture. To capture this range of spatial detail, it is advantageous to make use of a multi scale representation. Some works have used multi resolution techniques for iris feature extraction [13] and have proven high recognition accuracy.

$$G(x, y) = e^{-\pi[(x-x_0)^2/\alpha^2 + (y-y_0)^2/\beta^2]}\, e^{-2\pi[u_0(x-x_0)+v_0(y-y_0)]} \quad (3)$$

Where (x_0, y_0) specify position in the image, (α, β) specify the effective width and length, and (u_0, v_0) specify modulation, which has spatial frequency ω_0 =2020 vu +. The odd symmetric and even symmetric 2D Gabor filters are Daugman demodulates the output of the Gabor filters in order to compress the data.

B. Laplacian of Gaussian Filters

The Laplacian is a 2-D isotropic measure of the 2nd spatial derivative of an image. The Laplacian of an image highlights regions of rapid intensity change and is therefore often used for edge detection. The Laplacian is often applied to an image that has first been smoothed with something approximating a Gaussian Smoothing filter in order to reduce its sensitivity to noise [14]. The operator normally takes a single gray level image as input and produces another gray level image as output.

Following statistical features are extracted in this paper by using laplacian of Gaussian filter:-

(*a*) Mean

(*b*) Variance and

(*c*) Standard deviation of the circles

(*d*) Pixel correlation

Mean

$$\overline{X^c} = \sum_{i=1}^{N^U} X_i^c, \; c = \overline{1, C} \tag{4}$$

Variance

$$S^{C^2} = \frac{1}{N^{C-1}} \sum_{i=1}^{N^U} \left(X_i^c - \overline{X_i^c}\right)^2 \tag{5}$$

Std. deviation

$$d = \sqrt{\frac{1}{N^{C-1}} \sum_{i=1}^{N^C} \left(X_i^c - \overline{X_i^c}\right)^2} \tag{6}$$

Pixel correlation

R = corrcoef (X) returns a matrix R of correlation coefficients calculated from an input matrix X whose rows are observations and whose columns are variables. The matrix R = *corrcoef* (X) is related to the covariance matrix C = *cov* (X) by

$$R\,(i, j) = C\,(i, j) / \sqrt{(C(i, i)\, C(j,\, j))} \tag{7}$$

C — Number of circles in the segmented iris,

X_i^c — Intensity (gradient) value of ith pixel of the cth circle,

N^c — Number of pixels along the cth circle

These extracted features are stored in the database for Identification process. Using these features; an image can be viewed as a feature vector F_c, C =1, C of that image having desired number of circles. In order to encode features, the Wildes et al. [9] system decomposes the iris region by application of Laplacian of Gaussian filters to the iris region image. The filters are given as

$$\nabla G = \frac{1}{\pi\sigma^4}\left(1 - \frac{\rho^2}{2\sigma^2}\right) e^{-\rho^2/2\rho^2} \tag{8}$$

Where σ is the standard deviation of the Gaussian and ρ is the radial distance of a point from the centre of the filter. The filtered image is represented as a Laplacian pyramid which is able to compress the data, so that only significant data remains. Details of Laplacian Pyramids are presented by Burt and Adelson [24].

5. IRIS CODE MATCHING

The two iris code templates are compared by computing the hamming distance between them using equation 3.

$$HD = \frac{1}{n} \sum_{J=1}^{N} XJ\,(XOR)\,YJ \tag{9}$$

Where, X_j and Y_j are the two iris codes, and N is the number of bits in each template. The Hamming Distance is a fractional measure of the number of bits disagreeing between two binary patterns. The Hamming distance approaches is a matching metric employed by Daugman for comparing two bit patterns and it represents the number of bits that are different in the two patterns.

6. RESULTS

Table 1
Experimental Results Laplacian of Gaussian Filter for Statistical Feature

HD Criterion	*Observed false match rate (FAR %) In proposed method*
0.01	0 (experimentally)
0.02	0
0.03	0
0.04	0
0.05	0
0.06	0
0.07	1
0.08	1
0.10	1
0.15	1

Table 2
Experimental Results for Log-Gabor Wavelet

HD Criterion	*Observed False Match Rate (FAR) in Proposed Method*
0.01	0
0.05	0
0.10	0
0.15	0
0.20	0
0.22	0
0.24	1
0.30	1
0.35	1

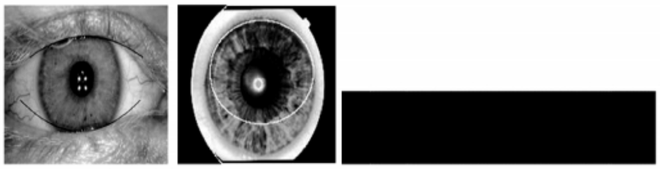

Fig. 4: CASIA Database

7. CONCLUSION

We have presented a novel method for iris recognition which utilizes both the intensity gradient (phase) and statistical analysis for feature extraction. The iris localization rate based on the popular Hough transform technique and the canny edge detection is that uses the gradient information and hence cannot work well when the gradient is not strong enough. We presented a novel approach to mask computation in the unwrapped image. We find that statistical feature analysis is very effective method for iris recognition. Thus an Iris Biometric system can establish a higher level of authenticity for security systems with high degree of accuracy and reliability. Hence such a system can be designed to protect the high security systems against hacking and cracking.

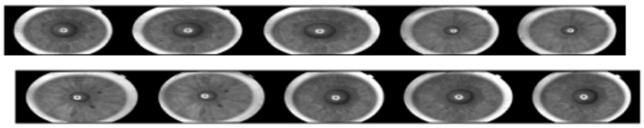

Fig. 5: Localized, Segmented, Normalized Iris Image

REFERENCES

[1] J.G. Daugman, "Complete Discrete 2-D Gabor Transforms by Neural Network for Image Analysis and Compression", *IEEE Trans. Acoust., Speech*, Signal Processing, **36**, pp. 1169-1179, 1988.

[2] L. Ma, Y. Wang. T. Tan, "Iris Recognition using Circular Symmetric Filters". *National Laboratory of Pattern Recognition*, Institute of Automation, Chinese Academy of Sciences, 2002.

[3] Tisse C.L., Martin L., Torres L., Robert M., "Person Identification Technique using Human Iris Recognition's", *Journal of System Research*, **4**, pp. 67-75, 2003.

[4] Daugman J, "High Confidence Visual Recognition of Persons by a Test of Statistical Independence", *IEEE Transactions on Pattern Analysis and Machine Intelligence*, **15 (11)**, November 2, June 2001, pp. 1148-1161.

[5] Gonzalez R.C., Woods R.E, Digital Image Processing, 2nd ed., Prentice Hall (2002).

[6] Lim S., Lee K., Byeon O., Kim T., "Efficient Iris Recognition Through Improvement of Feature Vector and Classifier", *ETRJ Journal*, **23 (2)**, June 2001, pp. 61-70.

[7] Bowyer K.W., Kranenburg C., Dougherty S. "Edge Detector Evaluation using Empirical ROC Curves", *IEEE Conference on Computer Vision and Pattern Recognition (CVPR)*, pp. 354-359, 1999.

[8] Canny J.F., "A Computational Approach to Edge Detection", *IEEE Transactions on Pattern Analysis and Machine Intelligence (IEEE TPAMI)*, **8 (6)**, pp. 769-798, 1986.

[9] Devernay F., "A Non-Maxima Suppression Method for Edge Detection with Sub-Pixel Accuracy", Research Report 2724, INRIA Sophia-Antipolis, 1995.

[10] Deriche R., "Using Canny's Criteria to Derive a Recursively Implemented Optimal Edge Detector", *International Journal of Computer Vision (IJCV)*, **1 (2)**, pp. 167-187, 1987.

[11] Heath M., Sarkar S., Sanocki T., Bowyer K.W., "A Robust Visual Method for Assessing the Relative Performance of Edge Detection Algorithms", *IEEE Transactions on Pattern Analysis and Machine Intelligence (TPAMI)*, **19 (12)**, pp. 1338-1359, 1997.

[12] Jain R., Kasturi R., and Schunk B.G., "Machine Vision", McGraw-Hill, 1995.

[13] Marr D., Hildreth E., "Theory of Edge Detection", *Proceedings of Royal Society of London*, **207**, pp. 187-217, 1980.

[14] Shin M., Goldgof D., Bowyer K.W., "An Objective Comparison Methodology of Edge Detection Algorithms for Structure from Motion Task", *IEEE Conference on Computer Vision and Pattern Recognition (CVPR)*, pp. 190-195, 1998.

[15] Y. Zhu, T. Tan, and Y. Wang, "Biometric Personal Identification Based on Iris Patterns", *International Conference on Pattern Recognition (ICPR'00)*, **2**, pp. 2801, Sept. 2000.

[16] S.R. Ganorkar, Dr. A.A. Ghatol, "Iris Recognition: An Emerging Biometric Technology", *Proceedings of International Conference ICSCI 2007*, Hyderabad, pp. 596-600, January 03-07.