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Personal Identity Recognition Approach Based on Iris Pattern

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1. Introduction

Personal identification based on biometrics technology is a trend in the future. Traditional approaches, for example, keys, ID cards, username and password, are neither satisfactory nor reliable enough in many security fields, biometrics authorizations based on face, iris, fingerprint have become a hot research filed. In those methods, iris recognition is regarded as a high accuracy verification technology, so that many countries have the same idea of adopting iris recognition to improve the safety of their key departments.

The human iris can also be considered a valid biometrics for personal identification [Richard P W, 1996]. Biometrics recognition based on iris patterns is a hotspot as face recognition and fingerprint recognition recently years. The iris is the colored ring on the human eye between the pupil and the white sclera. Lots of physical biometric can be found in the colored ring of tissue that surrounds the pupil, such as corona, crypts, filaments, flecks, pits, radial furrows and striations. The iris features can be encoded by mathematical representation so that the patterns can be compared easily.

In real-time iris recognition application system, iris localization is a very important step for iris recognition. The iris regions segmentation accuracy and localization real-time performance will affect the whole recognition system's correct rate and effectiveness for large-scale database.

Because iris region is a small object and has low grey value, it is very difficult to capture high contrast iris image clearly. In order to improve iris image contrast, usually some illuminations such as near infrared light source are used to increase intensity; however these illuminations may result in some faculas in iris image and affect iris segmentation and iris features.

Here, we will discuss iris recognition system's algorithm, all steps of iris recognition system will be introduced in details. Finally, we will show the experimental results based on iris database.

2. Iris recognition system principle

Iris feature is convenience for a person to prove his/her identity based on him/her biometrics at any place and at any time. Iris recognition may become the most important

identify and verify approach in many departments such as navigation, finance, and so on.

Iris recognition system main includes iris capturing, image pre-processing, iris region segmentation, iris region normalization, iris feature extraction and pattern matching. Every part is very important for correct recognition person identity.

There are plenty of features in iris regions of human eye image. Because iris is a small and black object, iris image capturing is not an easy work. Iris must be captured at a short distance about 4cm-13cm and under a good illumination environment. Near infrared is a better light resource for many visible image recognition systems, such as face recognition. Near infrared can perform good illumination for enhancing image contrast and it is harmless to human eyes. In order to capture ideal iris image, it is necessary that a friend cooperation of user and captured camera is the base of iris recognition. A good cooperation can decrease the quantity of iris pre-processing and improve iris recognition real-time character. However, the demand for cooperation may affect user's feeling and result in users doesn't accept iris recognition system because of high rejection rate. So, many researchers begin to study imperfect iris recognition theory under in-cooperation conditions, iris recognition system will have more width application fields based on imperfect iris recognition theory under in-cooperation conditions.

Because of motion blur or defocus blur or the occluder like eyelids and eyelashes, objective evaluation algorithm of image quality can be used to select a high quality eye-image for iris recognition. Now, some literatures evaluate images by using features of frequency domain and spatial domain and by calculating the rate of effective iris regions' pixels to whole iris regions' pixels. Image quality evaluation is a step to select an eye-image for iris recognition, and this procedure can decrease processing work according to lower quality eye-images.
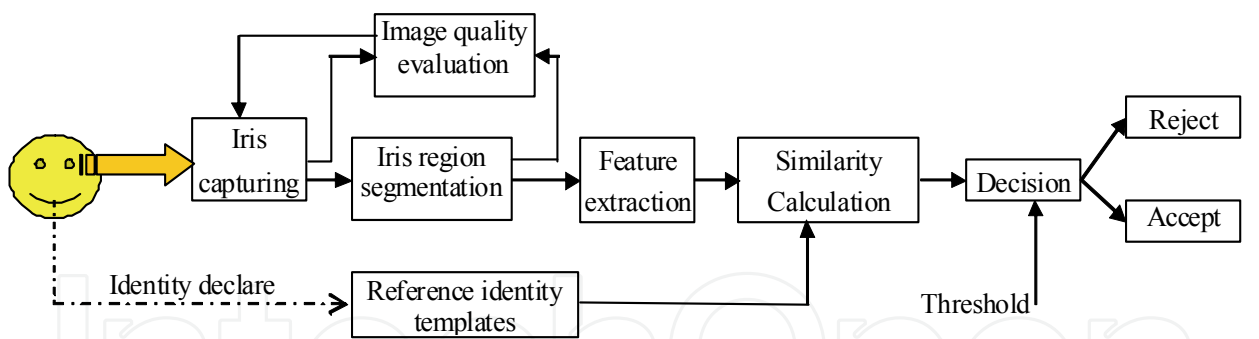

Fig. 1. Iris recognition system principle

3. Iris region segmentation

3.1 Iris segmentation background

In iris recognition system, iris region is the part between pupil and sclerotic, the aim of iris boundary localization is to locate the boundary of iris/pupil and the boundary of iris/sclerotic. Both inter boundary and outer boundary of iris are alike circles, so many iris localization methods are to locate iris boundaries using circle detector. John Daugman's Integral-differential method and Wildes's Hough transform method are effective methods for iris localization precision [John Daugman, 1993; Richard P W, 1997], but those methods cost lots of compute times because of large parameters search space. In order to improve iris localization real-time performance, many modified algorithms adopting some known

information of iris image are introduced in other literature. Pupil position can be estimated easily because of the lower grey level in pupil region and then iris boundary localization speed can be improved based on pupil position localization. Fast iris localization based on Hough transforms and inter-gradational method can be realized at the base of pupil position estimation [Tian Qi-chuan, 2006].

Usually, there is much interference in iris regions, and the interference can cause iris texture and grey value change, so high accuracy iris segmentation also need to remove the interference.

3.2 Iris boundary localization based on Hough transforms

In iris boundary localization methods, John Daugman's Integral-differential method and Wildes's Hough transform method with high iris localization precision are the most popular and effective methods, but the real-time character of those methods can't be satisfied. At the same time, these methods also have its disadvantages. Integral-differential method will be affected by local gradient maximum easily and then iris boundaries are located in these wrong positions, main reason is that light-spots will produce great gradient change. Hough transform for circle parameters voting can decrease local gradient effect, but the threshold for extracting edge points will affect the number of edge points and finally these edge points will cause iris boundary localization failure.

Fast boundaries localization based on prior pupil centre position estimation can improve iris boundary localization real-time, the main idea of this algorithm is: firstly, pupil centre coarse localization, secondly, edge detection based on canny operation; thirdly, iris inter boundary localization in a small image block selected; fourthly, edge extraction based on local grey gradient extreme value; finally, outer boundary localization in image block selected based Hough transform.

3.2.1 Pupil center coarse localization

In eye image, there are obvious lower grey levels in pupil regions than other parts as shown in Fig.2. Firstly, a binary threshold can be selected based on Histogram adopting p-tail method. Usually, iris image is captured in a distance, so pupil size is limited to a range in eye image, we can select threshold depend on the set rate of pupil pixels number to whole image pixels in histogram. Faculas can be seen in eye image as shown in Fig.2, these interferences must be removed, or they will affect iris boundary localization.
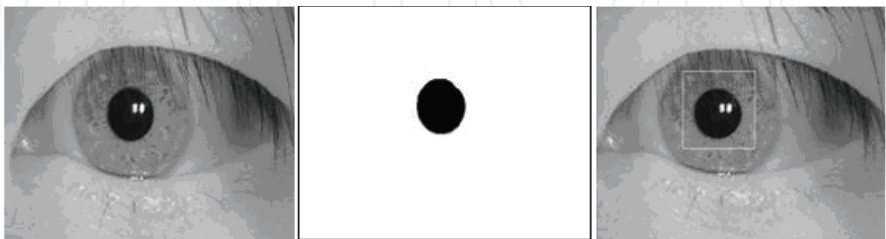
a) Original eye image   b) Binarized result   c) Pupil coarse estimation

Fig. 2. Pupil centre coarse localization

According to high grey pixels caused by faculas in pupil parts, morphological operation can be used for filling with these holes and remove noise such as eyelashes by using close-operation. So the original image of Fig.2 (a) can be transformed into the image of Fig.2 (b).

After removing light-spots, pupil centre position will be estimated more accuracy, it is helpful to precision iris localization.
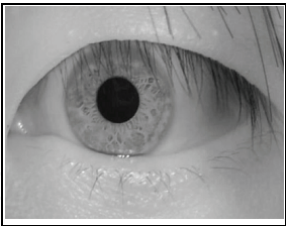

Fig. 3. Results of morphological operation

We can find a position using a moving window, when the window move to a position, the number of pixels in the window can be calculated, thus the position responding to the minimum sum can be regarded as pupil centre. The ordinate parameters (x, y) of pupil centre can be calculated as formula (1).

$$\begin{cases} x = \dfrac{1}{N}\sum_{i=1}^{N} x_i \\[2mm] y = \dfrac{1}{N}\sum_{i=1}^{N} y_i \end{cases} \tag{1}$$

Where, (x_i, y_i) indicate 0-pixel ordinates, N is the number of 0-pixel points.
Pupil centre coarse estimation result is shown in Fig.2 (c).

3.2.2 Iris inter boundary delicate localization

At the base of pupil centre coarse localization, small region as n*n can be selected for pupil boundary localization, in this small region, we can achieve several local gradient extreme value points as binary edge points, then these points are divided into two sets (named left-set and right-set) according to their position direction to the pupil centre estimation, and we can take every point of left-set and every point of right-set as a pair points, so we can achieve n*n pairs data, the centre and radius of pupil boundary can be confirmed by every pair data voting for $h(x, y, r)$ as follows formula (2). Fig.4 is the principle of pupil boundary localization.
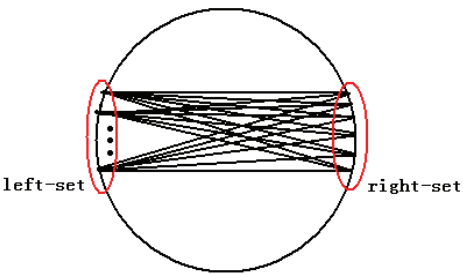

Fig. 4. Result of pupil boundary localization

$$h\left(\frac{x_i + x_j}{2}, \frac{y_i + y_j}{2}, \sqrt{(x_i - x_j)^2 + (y_i - y_j)^2} \right) + + \tag{2}$$

When finished all voting, we can achieve the pupil boundary parameters by using formula (3). Fig.5 is the pupil localization result.

$$H(x_p, y_p, r_p) = \max\left\{\bigcup h(x, y, r)\right\} \tag{3}$$
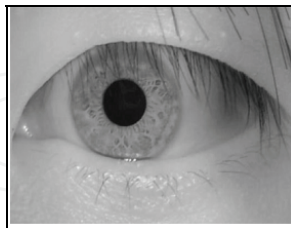

Fig. 5. Results of morphological operation

3.2.3 Iris outer boundary localization

In this paper, in order to realize iris boundary fast localization, a new method is proposed to extract iris edge points by using local gradient extreme value for each line of image, and then to achieve iris boundaries' parameters based on new voting approach. The upper eyelid and the lower eyelid often corrupt iris outer boundary, so we locate iris outer boundary by using part edge information.

Because iris outer boundary has lower gradient than iris inter boundary (pupil boundary), it is very difficult to extract edges by comparing with a set threshold. If the threshold for edge extraction in iris gradient image is lower, then the more edge points extracted will be not helpful to improve real-time character of iris recognition system and the more edge points also may cause iris localization failure; if the threshold for edge extraction in iris gradient image is higher, then many edge points may be lost and it also can cause iris localization failure. So, we want to extract edge information by using local grey gradient extreme value, then to locate outer boundary based on Hough transform.

Here, we don't select the threshold to extract edge points, instead of this, while we achieve binary edge points by comparing every line's grey gradient extreme value. The principle is shown in Fig.6. Same as pupil region selection, an image block for iris outer boundary localization can be selected so that we can locate iris boundary in a small region. Because upper eyelid usually obstruct iris region, we can select a small region for iris outer boundary localization as shown in Fig.6. Thus, based on Hough transform, we can adopt fewer edge points to achieve accuracy iris boundary. Fig.7 is the results of iris boundary localization.
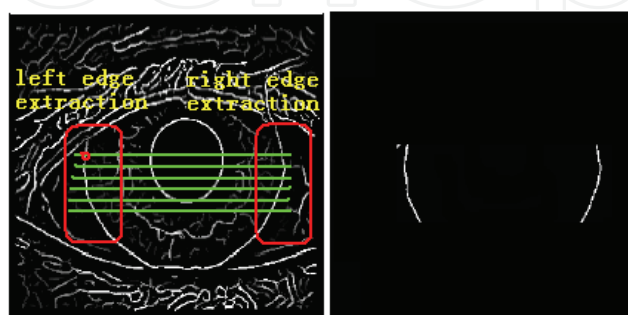
a) Gradient image   b) Binary image

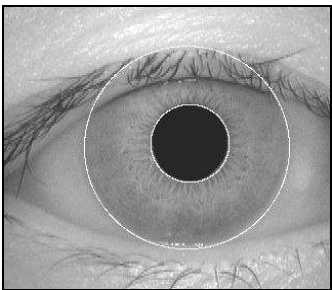Fig. 6. Binary edges extract principle based on line grey gradient extreme value

Fig. 7. Iris boundary localization results

Iris boundary localization algorithm is as follows:
Step 1. Pupil centre coarse localization;
Step 2. Select a small image block and extract edge information based on canny operator;
Step 3. Pupil boundary localization based on Hough transform;
Step 4. Select a small image block and extract edge information based on line's grey gradient extreme value;
Step 5. Iris outer boundary localization based on Hough transforms.

Due to improve localization speed and localization accuracy, taking the advantage of the grey information, we decrease the number of edge points and parameter range down to a small range to locate iris boundary.

3.3 Interference detection

There are many images looks like which shown in Fig.8. In iris images captured, interference, such as eyelids, eyelash and facula, will affect iris effective information for iris recognition [Wai-Kin Kong & David Zhang, 2003], we must remove these interferences between pupil boundary and iris outer boundary. From image #1 to image #4, we can see that eyelids cover iris's upper part and lower part usually. So, to detect boundary of eyelid is an important step in accuracy segmentation iris region.

a) Image #1   b) Image #2   c) Image #3   d) Image #4
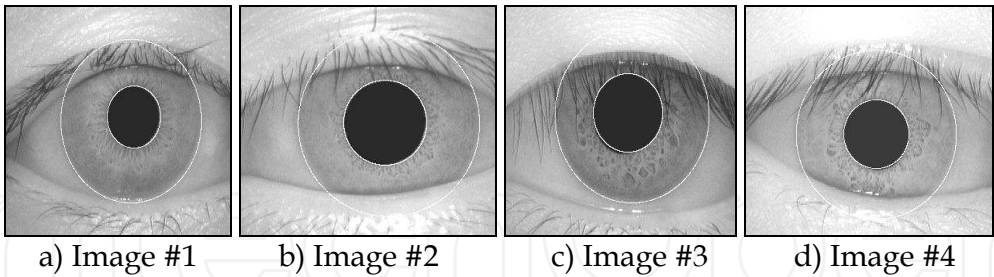
Fig. 8. Eye images

In order to achieve high accuracy segmentation and extract effective iris information in iris region, interference of eyelids, eyelash and faculas should be detected at a high accuracy rate [W. Kong & D.Zhang, 2001; Tian Qi-chuan, 2006]. Interferences detection is the other important aspect in segmenting iris region. Some image processing technologies are used to improve robustness of the algorithm to remove the interference of eyelash, light spots and image contrast. For every eyelid, using three-line detection can approach the eyelid. In order to get effective iris features, self-adaptive algorithms of detecting eyelid and eyelash and faculas are introduced in iris segmentation.

In some literature, four kinds of methods are introduced to remove eyelids as shown in Fig.9. The first method remove eyelids by using arc Hough transform to fit eyelid's

boundary, this method has a performance with high accuracy and low speed. The second method locate eyelids by line eyelids boundary localization to remove the affection of eyelids in iris recognition, this method has good real-time performance. The third method thinks iris regions near outer boundary has fewer distinguishable features and disturbed easily by eyelids, so a ring-band region can be removed and a ring-band near pupil's boundary can perform enough distinguishable information for iris high accuracy recognition. The fourth method is to locate eyelids based on multi-line's detection, and this method has lower compute cost and high eyelids localization accuracy.

a) Arc detection method   b) Line detection method

c) Circular method   d) Straight line to fit eyelid boundary
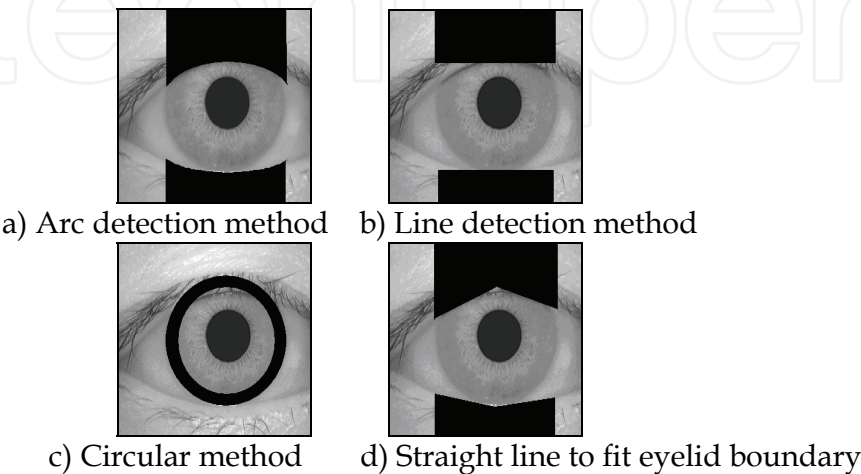
Fig. 9. Several principles for eyelids removing

Enough effective information will be helpful to iris recognition, so we select the fourth method mentioned above to locate iris eyelids. Firstly, horizontal edge can be extracted from eye image as shown in Fig.10, then radon transform is used in line localization to indicate eyelids outlines responding to four parts divided based on pupil centre position as shown in Fig.11. From the localization results we can see that the retained iris region has very high signal noise rate.
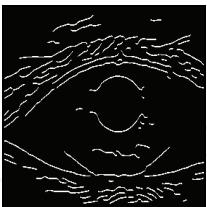

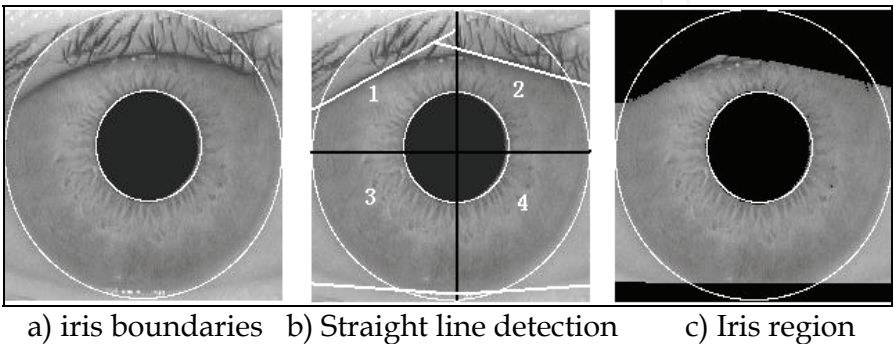Fig. 10. Binary edge image for eyelids detection

a) iris boundaries   b) Straight line detection   c) Iris region

Fig. 11. Eyelids detection principle

Eyelid detection algorithm as follows:

Step 1. select small image block based on iris boundary's parameters;

Step 2. extract edge based on gradient operator and divide the selected image block into four parts;

Step 3. locate four lines as eyelid's boundaries based on radon transform.

4. Iris region normalization

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 cases of inconsistency include, varying imaging distance, rotation of the camera, head tilt, and rotation of the eye within the eye socket. The normalisation 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. Here we normalize iris circular region into rectangular region, the procedure is named as iris region normalization.

As we all known, another point of note is that the pupil region is not always concentric within the iris region, and is usually slightly nasal. Even we have achieved the parameters of iris boundaries, iris normalization that how to transform different resolution image into the same resolution rectangular region still is a problem. Usually, we can realize iris normalization by sampling M along with angle direction and sampling N along with radial direction. Fig.12 is an iris plastic model used to normalize iris region, we can indicate whole iris region by using the grey information of these pixels determined by coordinates combines of inter boundary and outer boundary [Libor Masek, 2001].
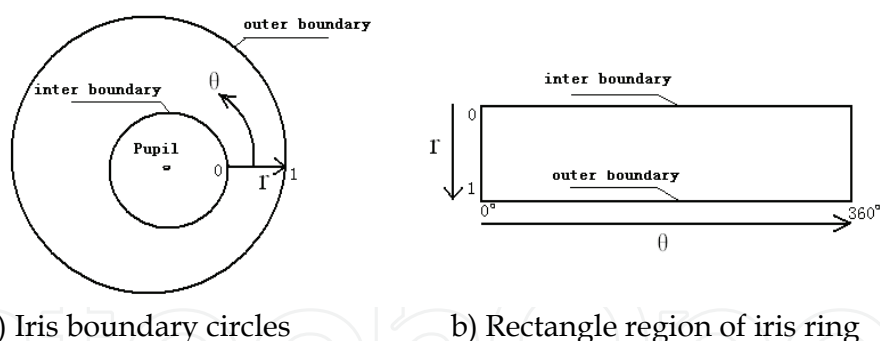

a) Iris boundary circles   b) Rectangle region of iris ring

Fig. 12. Rubber sheet model

The homogenous rubber sheet model 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 $(0°, 360°)$. $I(x,y)$ is Cartesian coordinate of iris images, and $I(r,\theta)$ is corresponding polar coordinate. (x_p, y_p) is the unit of inner boundary in Cartesian coordinate, (x_l, y_l) is that of outer boundary, then coordinate transform is defined as follow:

$$I(x(r,\theta), y(r,\theta)) \rightarrow I(r,\theta) \tag{4}$$

$$\begin{cases} x(r,\theta) = (1-r)x_p(\theta) + rx_l(\theta) \\ y(r,\theta) = (1-r)y_p(\theta) + ry_l(\theta) \end{cases} \tag{5}$$

In above equation, $r = \dfrac{i}{M+1}, i = 1,2,...,M$, $\theta = \dfrac{j}{N} \cdot 360°, j = 1,2,...,N$ ，M is sample rate along with angle direction and N is sample rate along with radial direction [C.H.Daouk, 2002]. If we choose small M and N , then low iris template size will be achieved [Raul Sanchez-Reillo,2010]. After boundary location and coordinate standardization, iris is showed as rectangular region (i,j) .

If the sample number along circle is set to N , the sample number along radius is set to M , and then iris region can be transformed into a rectangle of $M \times N$ pixels. The details of normalization algorithm as follows:

Step 1. Achieve the parameters of (x_p, y_p, r_p) and (x_o, y_o, R_l) based on iris boundary localization on iris image $I(x,y)$;

Step 2. Calculate the distance between pupil centre and iris centre, and achieve connection direction angle;

$$\begin{cases} \phi = \arctan \dfrac{y_p - y_o}{x_p - x_o} \\ \Delta r = \sqrt{(x_p - x_o)^2 + (y_p - y_o)^2} \end{cases} \quad (6)$$

Step 3. Select the centre of pupil as pole, then every point of iris inter boundary has the same formula $r(\theta) = r_p$ in polar coordinates, the sample point's position along iris outer boundary will be achieved as follows:

$$\begin{cases} \theta = j \times \pi / 180 \\ R(\theta) = \Delta r \cos(\pi - \theta - \phi) \\ \quad + \sqrt{R_l^2 - \Delta r^2 + (\Delta r \cos(\pi - \theta - \phi))^2} \end{cases} \quad (7)$$

where $j = 1,2,\cdots,N$.

Step 4. Every pixel's grey information of normalization iris region can be achieved using those grey of (x,y) positions confirmed as follows:

$$\begin{cases} Rp = (1 - \dfrac{i}{M+1}) \times r(\theta) + \dfrac{i}{M+1} \times R(\theta) \\ x = Xp + Rp\cos(\theta) \\ y = Yp - Rp\sin(\theta) \\ Normalrize\_Iris(i,j) = I(x,y) \end{cases} \quad (8)$$

where, $i = 1,2,\cdots,M$, $j = 1,2,\cdots,N$ ，$\theta = j \times \pi / 180$.

After removing the first line and the last line, we will achieve iris normalization region of $M \times N$. Fig.13 (a) is an iris image, (b) is sample image, and (c) is the normalization result. From Fig.13, we can see that interference caused by eyelash and eyelid change iris texture, so we must label these interference so that we can eliminate these interference in pattern match. Fig.14 shows the label results according interference in iris normalization region.
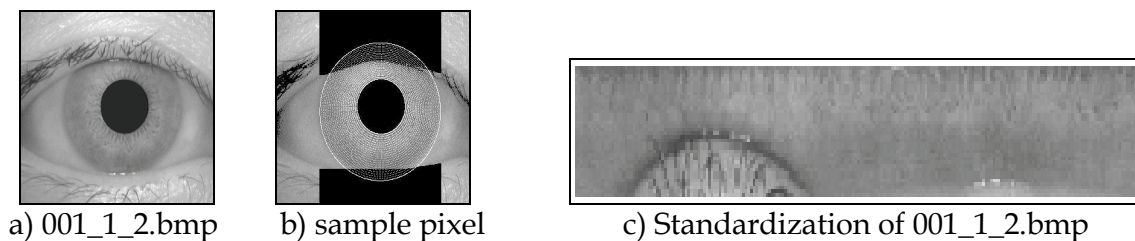
a) 001_1_2.bmp   b) sample pixel   c) Standardization of 001_1_2.bmp

Fig. 13. Standardized rectangular region

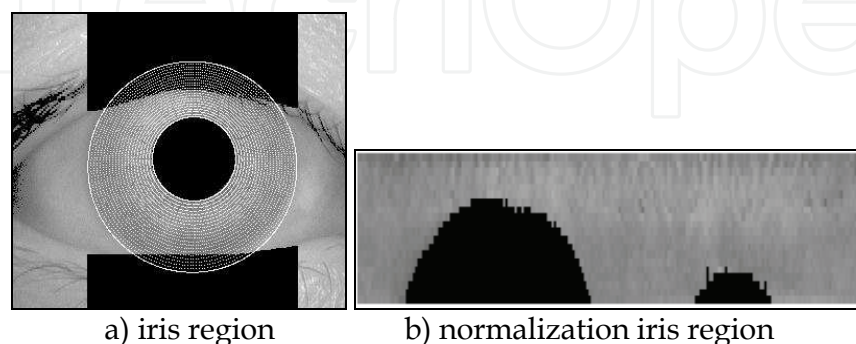a) iris region   b) normalization iris region

Fig. 14. Interference label in Iris normalization region: iris image after boundary localization and interference localization (left) and the corresponding normalization iris region with the labeled interference (right)

5. Iris feature extraction based on local binary pattern analysis

5.1 Iris feature extraction based on local binary pattern

Iris recognition algorithms main include Gabor filter method, local zero-crossing wavelet, independence complements analysis, and so on [Li Ma, 2004; Kwanghyuk Bae, 2003; Tian Qi-chuan, 2006; Seung-In Noh, 2002]. The binary ordinal of iris texture has become iris recognition frame. Iris binary template is stored as personal identify feature reference template in the future. From these algorithms, we learn of that iris recognition adopts local features to indicate iris pattern [Zhenan Sun, 2004], here, we introduce a new algorithm based on local binary pattern analysis for iris recognition.

Local Binary Pattern (LBP) is an easy-to-compute, robust local texture descriptor, and it has been shown to be promising in the computer vision field, including industrial inspection, motion analysis, and face recognition. In this paper, we show that LBP can solve iris feature extraction according the inherent intensity-related texture problem, is robust to some illumination and interference, and has potential for pattern recognitions [W.W.Boles, 1998; Devrim Unay, 2007; T. Ahonen, 2006].

For instance, in iris region, image intensity smoothly varies across an image. This intensity inhomogeneity, or socalled bias field, can significantly degrade the performance of some recognition algorithms. Because the bias field is locally smooth, we argue that it should not change the local structure. Furthermore, in iris acquisition inter- and intra-user misalignment of the images is a known problem. This misalignment problem may limit the application of automated match on iris images. In this case, rotation invariant descriptors may prevent some of those limitations.

LBP is a grayscale invariant local texture operator with powerful discrimination and low computational complexity. An LBP operator thresholds a neighborhood by the gray value of

its center (g_c) and represents the result as a binary code that describes the local texture pattern. The operator ($LBP_{P,R}$) is derived based on a symmetric neighbor set of P members $g_p(p = 0, \cdots, P-1)$ within a circular radius of R.

$$LBP_{P,R} = \sum_{p=0}^{P-1} s(g_p - g_c)2^p \qquad (9)$$

where

$$s(x) = \begin{cases} 1, x \geq 0 \\ 0, x < 0 \end{cases} \qquad (10)$$

Fig. 15 illustrates the computation of $LBP_{8,1}$ for a single pixel in a rectangular 3×3 neighborhood. Binary feature is more robust than image magnitude character.

109	45	72
55	50	4
67	98	34

$\longrightarrow$

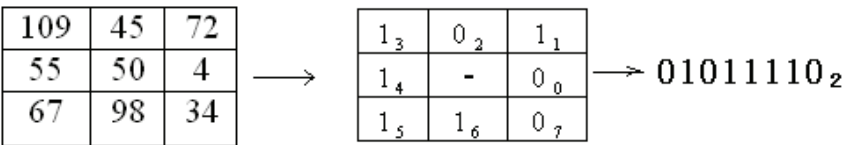| 1_3	0_2	1_1
1_4	-	0_0
1_5	1_6	0_7

$\longrightarrow 01011110_2$

Fig. 15. Example of computing $LBP_{8,1}$: a pixel neighbourhood (left), its thresholded version (middle), and the corresponding binary LBP pattern with the computed LBP code (right)

In the general definition, LBP is defined in a circular symmetric neighborhood that requires interpolation of intensity values for exact computation. In order to keep computation simple, in this study we decided to use the two rectangular neighborhoods as shown in Fig.16.
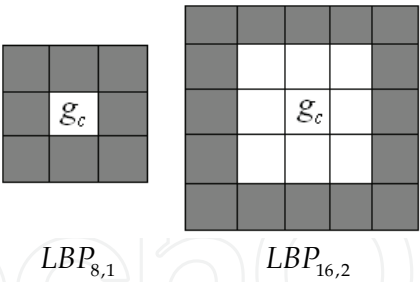

$LBP_{8,1}$ $LBP_{16,2}$

Fig. 16. The rectangular neighbourhoods of LBP used. Gray-shaded rectangles refer to the pixels belonging to the corresponding neightborhood

Rotation invariant patterns: The $LBP_{P,R}$ operator can produce 2^P different output values from P neighbor pixels. As g_0 is always assigned to be the gray value of neighbor to the right of g_c, rotation will result in a different $LBP_{P,R}$ value for the same binary pattern. Because iris region normalization have transform iris circular region into rectangular region, there aren't the effect of rotation.

So, Iris feature extraction algorithm based on local binary pattern can be written as follows:

Step 1. According to iris normalization region $I_{M \times N}$, we can move $LBP_{P,R}$ to location $I(i,j)$ in $I_{M \times N}$, and then we can achieve LBP codes at position (i, j), where $I(i, j) \in I_{M \times N}$, $i = 1, 2, \cdots, M, j = 1, 2, \cdots N$.

Step 2.   We can construct iris feature template based on these LBP codes.
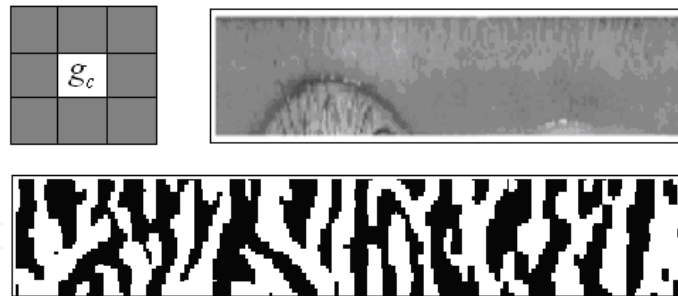

Fig. 17. Feature extraction based on LBP :(left-upper), iris normalization region (right-upper), and feature extraction results based on LBP (below)

5.2 Match score calculation

Because iris features belong to binary features, we can calculate match score by using vector similarity: if *A* and *B* are feature template vectors, then the similarity of *A* and *B* can be calculated as follows:

$$Similarity(A,B) = \frac{\langle A,B \rangle}{\|A\|\|B\|} \tag{11}$$

According to iris rotation, we can eliminate the effect of iris rotation by using shift operation on the binary pattern *A* several times and assign the $Similarity(A^{shift},B)$ that is the largest in similarity scores under different shift case:

$$Similarity(A^{shift},B) = \max_{shift \in \{8i|i=1,2\cdots\}} \bigcup \frac{\langle A^{shift},B \rangle}{\|A\|\|B\|} \tag{12}$$

5.3 Iris feature selection

Feature selection can be used to improve classification performance [Linlin Shen, 2005].The eyelid, eyelash and facula can affect iris character, so features of this area aren't true features and they should be removed after boundary location. The threshold segmentation method is used to eliminate eyelash and facula, and radon transform based on arc and line is used to detect eyelid. The purpose of interfere detection is to achieve iris region accurately. While we transform iris region into rectangular region, we also label the interference points in rectangular region. Those features of the interference part labelled should be removed in calculating pattern similarity score. Only those stable features is helpful to iris classify, however, how to know whether features are stable or not still is a research problem.

We think stable features is those features which are captured every time, exist in many iris image, and aren't affected by interference, so we want to train classifier by selecting stable features from intra serial iris images.

Step 1.   Select training data;

Step 2.   Calculate intra similarity of iris, the largest similarity score is defined to the similarity score of two iris feature pattern alignment under different shift cases, then label these same features of templates as stable features and label other features as unstable features;

Step 3. These templates with stable labels and unstable labels can be regarded as identity reference template.

In Fig.18, (a1) and (a2) are two eye images of the same person, and they are captured in different condition. Fig.18 (b1) and (b2) are normalization regions of (a1) and (a2), (c1) and (c2) are feature extraction results, and (d) is the feature selection result. In Fig.18 (c1), (c2) and (d), red pixels indicate '1' features, green pixels indicate '0' features, and black pixels in Fig.18 (d) indicate unstable features. Those unstable features should be removed when we calculate matching score.

a1) 001_1_1.bmp a2) 001_1_2.bmp

b1) normalization region of 001_1_1.bmp b2) normalization region of 001_1_2.bmp

c1) feature codes of 001_1_1.bmp c2) feature codes of 001_1_2.bmp

d) feature selection result
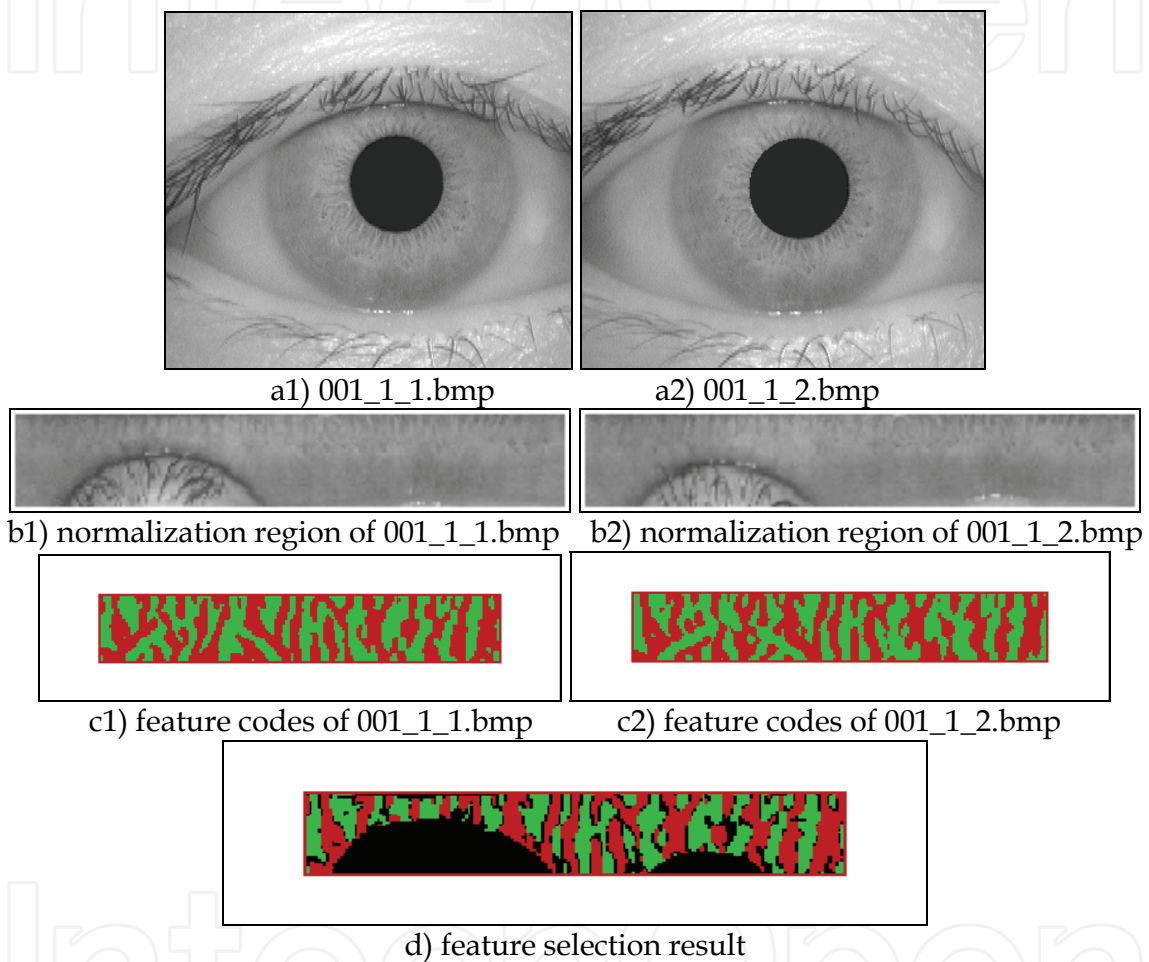
Fig. 18. Stable feature selection results

Feature selection is a method for improving pattern classification accuracy, in this paper, feature selection is to select stable and effectiveness features by comparing intra images of the same iris. In Fig.18, It can be seen that unstable features mostly appear at boundary of texture shape change. Those regions whose gray value changes mildly are less affected by illumination, therefore stable features are low frequency signal practically. Points on boundary, denote unstable characters, are easy to modify the sign of LBP detection. So selection key feature from multi-images is to describe image pattern based on stable low frequency character. Therefore, stable features should be found in images that have large difference, based on pattern mapping, complicated pattern could be mapped in the space that represented as some key features. It can enhance template description ability by making high dimension expression into low dimension.

5.4 Decision

Iris recognition used to for identity verification, after capturing iris image and extracting features, recognition system based on iris pattern can recognise user's identity using his/her iris by comparing similarity with a classification threshold.

Classification threshold can be achieved depend on classification performance on training data and demand on recognition real-time performance and recognition correct rate.

If whole reference templates are $W = \{w_1, w_2, \cdots, w_c\}$, *Threshold* is classification threshold, then the steps of iris recognition procedure can be written as follows:

Step 1. Extraction features P of a person iris images based on LBP;

Step 2. Calculation similarity degree $Similarity(P, T_{w_i})$ between P and reference identity templates T_{w_i};

Step 3. If $Similarity(P, T_{w_i}) > Threshold$, then the identity of the person can be confirmed and he/she belongs to w_i; otherwise $i = i + 1$, go to step2 until $i > c$.

6. Experimental results

Under this condition, the difference of similarity distribution between same iris pattern and the different ones can be converted into classifying as the same pattern and the difference pattern. The unrecognized images have 108 pattern 540 images totally, so there are 540 samples in same pattern, and there are 28890 samples in difference pattern [Chinese Academy of Sciences-institute of automation, 2003].

Fig.19 is the comparison of iris classification results based on LBP and feature selection and only based on LBP without feature selection. We can learn that there are very low error classification rate in Fig.19 (b1) and (b2). Tab.1 shows the performance of iris recognition. The distribution of similarity and error rate show the algorithm has good recognition performance.

Performance of classification algorithm includes FAR (False Accept Rate), FRR (False Reject Rate), EER (Equal Error Rate, it is defined to the value of FAR and FRR when FAR=FRR) and Decide-ability D defined as formula [John Dangman, 1993 & 2002; Shinyoung Lim, 2001]:

$$D = \frac{\left| \mu_{same} - \mu_{difference} \right|}{\sqrt{(\sigma_{same}^2 + \sigma_{difference}^2)/2}} \tag{13}$$

D denotes classified quality of training patterns, in which μ_{same}, $\mu_{difference}$, σ_{same}^2, $\sigma_{difference}^2$ are the means and variances of same class pattern and different class patterns respectively.

Performance	LBP Without feature selection	LBP with feature selection
EER	0.5%	0.45%
D	7.1	8.9

Table 1. Performance of LBP

7. Conclusion

We introduce a whole iris recognition system. Especially, when using only one image for iris recognition, the registered iris features are susceptible to illumination, contrast and other factors, resulting in a large number of trustless feature points in feature template. A method

based on LBP features extraction and selection from multiple images is presented, in which stable features are selected to describe the iris identity while the unreliable feature points are labelled in enrolment template. Research show LBP is robust to bias field and rotation. Overall performance of the iris recognition system is satisfied.
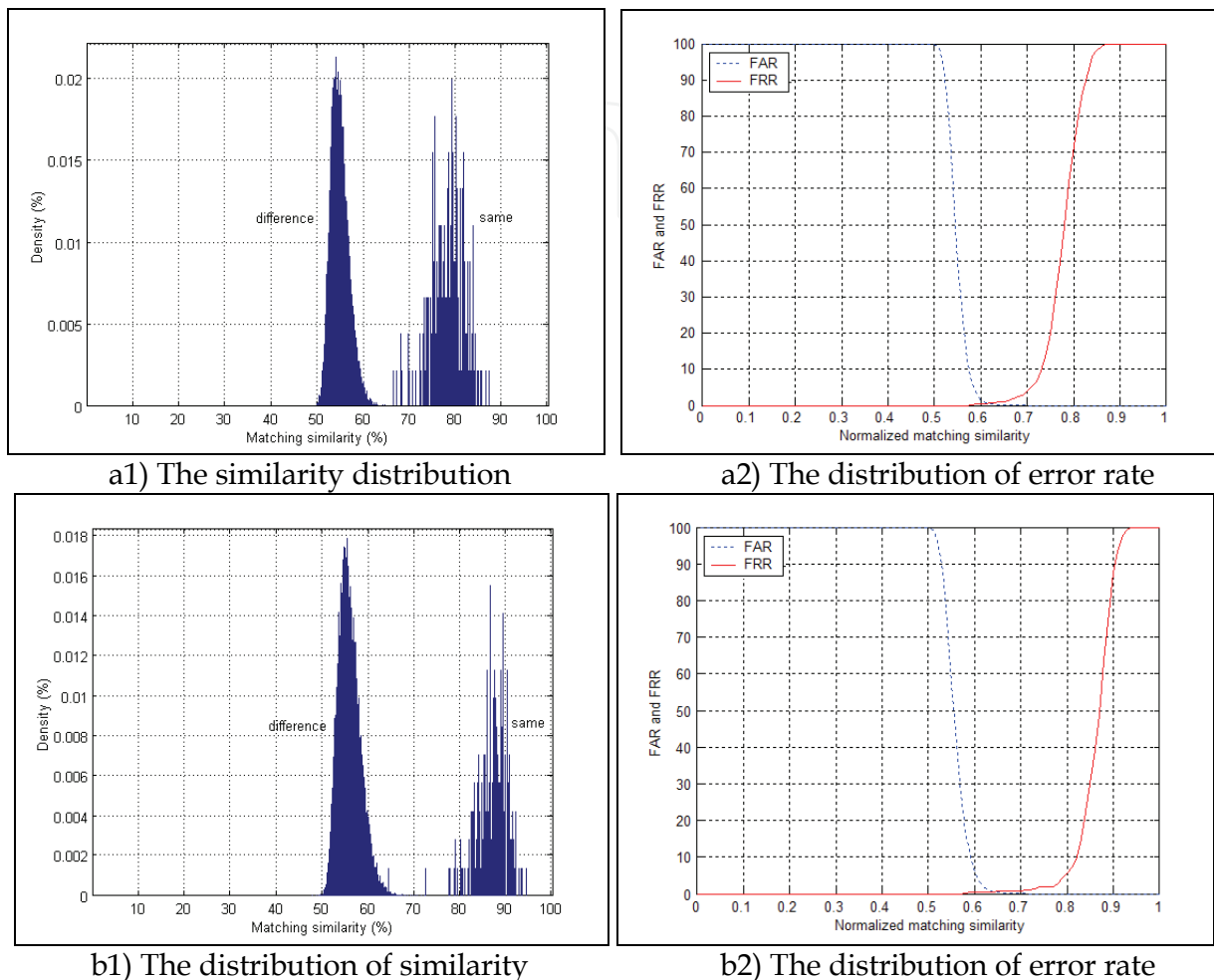

a1) The similarity distribution   a2) The distribution of error rate

b1) The distribution of similarity   b2) The distribution of error rate

Fig. 19. Experimental results, (a1) and (a2) is iris classification results without feature selection, (b1) and (b2) is iris classification results with feature selection

8. Acknowledgment

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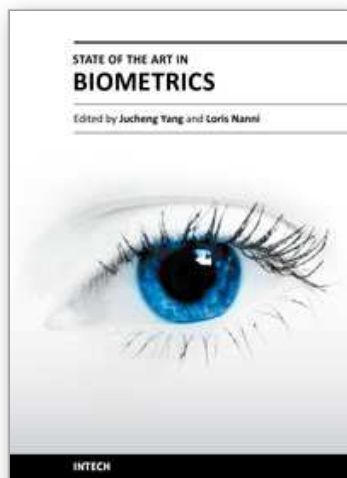
State of the art in Biometrics

Edited by Dr. Jucheng Yang

Biometric recognition is one of the most widely studied problems in computer science. The use of biometrics techniques, such as face, fingerprints, iris and ears is a solution for obtaining a secure personal identification. However, the â€œoldâ€ biometrics identification techniques are out of date. This goal of this book is to provide the reader with the most up to date research performed in biometric recognition and descript some novel methods of biometrics, emphasis on the state of the art skills. The book consists of 15 chapters, each focusing on a most up to date issue. The chapters are divided into five sections- fingerprint recognition, face recognition, iris recognition, other biometrics and biometrics security. The book was reviewed by editors Dr. Jucheng Yang and Dr. Loris Nanni. We deeply appreciate the efforts of our guest editors: Dr. Girija Chetty, Dr. Norman Poh, Dr. Jianjiang Feng, Dr. Dongsun Park and Dr. Sook Yoon, as well as a number of anonymous reviewers

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