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Iris Segmentation and Recognization Using Log Gabor Filter And Curvelet Transform

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ABSTRACT:

Biometric methods have been played important roles in personal recognition during last twenty years. These methods include the face recognition, finger print and iris recognition. Recently iris imaging has many applications in security systems. The aim of this paper is to design and implement a new iris recognition algorithm. In this paper, the new feature extraction methods according to log-gabor filters and curvelet transform for identifying the iris images are provided. Iris recognition is annular region between the sclera and the pupil of the human eye. In this region, there exists an extraordinary texture including many prominent features, on which the recognition is mainly relied. In the existing approach adopted the Scale invariant Feature Transform (SIFT) to extract the local feature points in both Cartesian and polar coordinate systems. Since it is very likely that many local patterns of the iris are similar, the recognition accuracy of the system based on SIFT is not as good as those of the traditional methods. A novel fuzzy matching strategy with invariant properties, which can provide a robust and effective matching scheme for two sets of iris feature points and the nonlinear normalization model, is adopted to provide more accurate position before matching. An effective iris segmentation method is proposed to refine the detected inner and outer boundaries to smooth curves. For feature extraction, instead of Log-Gabor filters we propose curvelet transform to detect the local feature points from the segmented iris image in the Cartesian coordinate system and to generate a rotation-invariant descriptor for each detected point. The proposed matching algorithm, which is based on the PFM method, is used to compare two sets of feature points by using the information comprising the local features and the position of each point.

KEYWORDS: Iris segmentation, Iris recognition, SIFT, Log Gabor filter, curve let transform, PFM.

"I. INTRODUCTION"

There are different methods for personal identification with using biometric characteristics. In general, biometric is an individual identification ability based on physiological characteristics such as fingerprint, handwriting, retina, iris and face. There are many advantages of employing biometric system for identification but there are also some disadvantages. We can mention to high recognition accuracy, uniqueness, and no needs to memorize a code as advantages and low public acceptance, and complex or expensive equipments as disadvantages. Any way the advantages of using the biometric systems are more than its drawback, so using is increasing daily.

Some characteristics of iris are: 1) it is formed in third month and completed in eight month of fetal term, 2) not only individual persons even twins but also left and right eye belong to a person have different iris pattern, 3) changing iris pattern without surgery with high risk is impossible. Pioneer work in iris recognition was proposed by Daugman [2]. Daugman's algorithm forms the basis of today's commercially used iris recognition systems. In [3], biometrics based on the concealment of the random kernels and the iris images to synthesize a minimum average correlation energy filter for iris authentication were formulated. In [4], the multiscale Gabor filters were used to demodulate the texture phase structure information of iris. In [5], an iris segmentation method was proposed based on the crossed chord theorem and the collarette area. In [6], iris recognition technology was applied in mobile phones.

In [7], correlation filters were utilized to measure the consistency of the iris images from the same eye. An iris image was decomposed in [8] into four levels by using the two dimentional (2D) haar wavelet transform, the fourth-level high-frequency information was quantized to form an 87-bit code, and a modified competitive learning neural network was adopted for classification. In [9], collarete area and daubechies in level 3 was used to extract useful features. In [10] feature extraction was based on multichannel Gabor filtering. Vladan in [16] used directionlet for feature extraction and Hamming Distance (HD) for classification. Gabor filter was applied to extract features according to phase specifications of iris features and finally in one dimensional (1D) coiflet was used to extract features.

In this paper propose a novel fuzzy matching strategy with invariant properties for two sets of local feature points. Proposed system is that try to provide an alternate feature extraction method to avoid the unwrapping preprocessing by extracting features from the iris image directly. A Log-gabor filter and curvelet transform are used to detect the local feature points and to generate a feature vector for each point. The proposed matching algorithm, which is based on the Possibilistic Fuzzy Matching (PFM) method, compares a pair of feature points by considering not only their local features but also the relative positions to all the other points.

A PFM algorithm for a pair of point set by combining the fuzzy alignment algorithm with the possibilistic FCM model. Both the position and local feature vector of each point are used to estimate the pose transformation and the point correspondence. A novel curve detection method is proposed to extract the inner and outer boundaries of the iris from a gray-level image

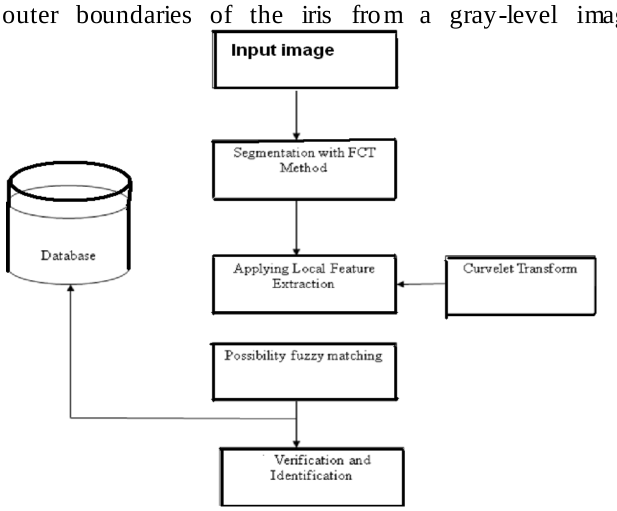


Fig. 1 – Block diagram for the proposed mode

2. IRIS IMAGE PROCESSING

Iris image processing includes three stages; they are segmentation, normalization and verification. In addition, for iris processing we need a standard database.

2.1 Segmentation

The inner and outer iris boundaries should be segmented to provide useful information area for identification. As pupil is black circular region, it is detected easily. The novel curve detection method is proposed to extract the inner and outer boundaries of the iris from a gray-level image. An eye image contains not only the iris texture but also some irrelevant parts. The papillary and limbic boundaries should be detected to isolate the annular iris region. In this section, we describe the Fuzzy Curve-Tracing (FCT) algorithm [18],[19] which can be used to detect a curve in a binary image. Then, we extend the FCT algorithm to extract a smooth curve from a gray-level image. The new FCT method can be applied to detect the inner and outer boundaries of an iris to segment the iris region.

A - FCT Algorithm:

The FCT algorithm based on the fuzzy c-means with a smoothness constraint function was proposed to extract a smooth curve from a binary image [27]. Assume that the set of input data is $X=\{x_1,x_2,....,x_n\}$, which denotes the set of positions of the foreground pixels in the binary image. Let $V=\{v_1,v_2,....,v_n\}$ be the set of cluster centers used to represent a smooth curve for the foreground pixels X. The cost function of the original FCT algorithm for a closed curve is defined as follows:

$$J_{FCT}(U,V;X)=\sum_{i=1}^{n}\sum_{k=1}^{c}\mu_{ik}^{m}\left\|x_i-v_k\right\|^2+\alpha\sum_{k=1}^{c}\left\|v_{k+1}-2v_k+v_{k-1}\right\|^2 \quad (1)$$

where α and m are Lagrange multiplier and the fuzzifier, respectively, and $U=\{\mu_{ik}\}$ is the set of membership values representing the degree of x_i belonging to the cluster with center v_k. Similar to the FCM algorithm, by setting the partial derivatives of the Lagrangian function J_{FCT} with respect to μ_{ik} and v_k to zero, both solutions of membership values and cluster centers can be iteratively computed. Then, a smooth curve V which represents the set X can be obtained.

B – FGCT Method:

The original FCT method can only produce a smooth curve represented by the cluster centers to fit the foreground pixels in a binary image. In order to apply the FCT algorithm, the gray-level (gradient) image has to be converted to a binary image. However, for an iris recognition sstem, it is difficult to automatically select a threshold for both inner and outer boundaries of the iris. Therefore, in our approach, the FCT method is modified to extract a smooth curve directly from the gray scale gradient image.

Assume that $G=\{g_1,g_2,....,g_n\}$ is the set of gray scale values in an image and $X_G=\{x_{g_1},x_{g_2},....,x_{g_n}\}$ is the set of corresponding positions of the elements in G. The cost function of the Fuzzy Gray scale Curve-Tracing (FGCT) algorithm is designed as follows :

$$J_{FGCT}(U,V;X_G)=\sum_{i=1}^{n}\sum_{k=1}^{c}\beta_i\mu_{ik}^{m}\left\|x_{g_i}-v_k\right\|^2+\alpha\sum_{k=1}^{c}\left\|v_{k+1}-2v_k+v_{k-1}\right\|^2 \quad (2)$$

where α and m are Lagrange multiplier and the fuzifier, respectively, and μ_{ik} is the membership value with the following constraints :

$$\mu_{ik}\in[0,1],\ \ for\ 1\le i\le n\ and\ 1\le k\le c$$

$$\sum_{k=1}^{c}\mu_{ik}=1,\ \ for\ 1\le i\le n. \quad (3)$$

The parameters $\beta_i's$ are the intensity weight of the i^{th} foreground pixel and are defined as

$$\beta_i=\frac{g_i-\min(G)}{\max(G)-\min(G)},\ \ for\ i=1,2,....,n \quad (4)$$

The input sample with a larger pixel value is more important than those with lower pixel values. In other words, cluster centers will attempt to move toward image pixels with larger intensity. Similar to the FCM algorithm,

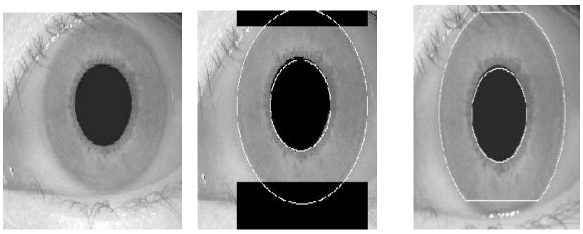
μ_{ik} can be estimated by using the following equation at each iteration step :

$$\mu_{ik} = \frac{\left\| x_i - v_k \right\|^{-2/(m-1)}}{\sum_{j=1}^{c} \left\| x_i - v_j \right\|^{-2/(m-1)}} \quad (5)$$

To solve $\frac{\partial J_{FGCT}}{\partial v_k} = 0$, we can obtain the update equation of each cluster center for a closed curve

$$v_k = \frac{\alpha(-v_{k-2} + 4v_{k-1} + 4v_{k+1} - v_{k=2}) + \sum_{i=1}^{n} \beta_i \mu_{ik}^m x_i}{6\alpha + \sum_{i=1}^{n} \beta_i \mu_{ik}^m} \quad (6)$$

Note that the index of cluster should be circularly arranged for a closed curve. In other words, v_{-1}, v_0, v_{c+1} *and* v_{c+2} should be treated as v_{c-1}, v_c, v_1 *and* v_2 respectively. The proposed iris segmentation consists of two stages. First, the gradient image around the iris boundaries in the radial direction from the pupil to the sclera is generated. Generally, the pupil is darker than the iris, and the iris is darker than the sclera. Therefore, the pixel values around the iris boundaries in the gradient image are positive. Accordingly, if any pixel value in the gradient image is smaller than zero, it should be set to zero. The FGCT method is then applied to extract a smooth curve of each boundary from the gradient images. The proposed iris segmentation method is shown in Fig. 2.



(a) **(b)** **(c)**

Fig. 2 – (a) Original image, (b) Image with noise and (c) Segmented Image

2.2 Normalization

Even iris images that are taken from the same person and in the same place are generally different, so obviously it is true for those captured at different time and different places. Pupil elastic deformation affects the iris size. Due to compensate the iris size variation, iris normalization is an obligation. As the inner and outer boundaries are approximately circle shape, we do iris normalization by using curvelet transform.

2.2.1 Feature extraction:

After feature extraction, the matching algorithm is essential to the comparison of two sets of points extracted from different iris images. In this section, we propose an effective matching algorithm with scale invariant, translation invariant, and rotation semi-invariant properties for two sets of local feature points. A novel matching method is proposed to compare two feature point sets by taking into consideration the information comprising the curvelet features and the position of each point. Finally, a matching score for two different iris images can be computed. The main contribution of this paper is the proposed matching algorithm, which can provide a novel, robust, and effective matching scheme for the feature points obtained from the curvelet transforms. In addition, the nonlinear normalization model is adopted to provide more accurate feature before matching.The fuzzy algorithm mentioned previously may suffer from a problem of outliers because of the constraint. Unfortunately, in pose transformation estimation, it is inevitable to have outliers when two point sets are partially matched, which occurs frequently in our application. Moreover, noise will cause some erroneous estimation and will generate undesirable outliers in practice. A solution of the outlier problem in clustering is to use a possibilistic model that relaxes the column sum constraint. This relaxation increases the freedom of weighting and makes it possible to reduce the effect of outliers by ignoring them. However, the possibilistic model is very sensitive to initializations and may cause coincident clusters. The possibilistic fuzzy algorithm can be written as follows. Let the local feature set and the corresponding position set of an iris template I1 be denoted as V1 = {V1 i :i = 1, . . . , n1} and Y = {yi : i = 1, . . . , n1}, and let those of a test image I2 be denoted as V2 = {V2 j : j = 1, . . . , n2} and X = {xj : j = 1, . . . , n2}, respectively. The energy function of the PFM is defined as follows

$$E_{PFM}(I^1, I^2) = \sum_{i}^{n_1} \sum_{j}^{n_2} (a\omega_{ij}^p + bt_{ij}^q) \times D_S(i,j) + \sum_{j}^{n_2} \gamma_j \sum_{i}^{n_1} (1 - t_{ij})^q \quad (7)$$

The proposed PFM algorithm attempts to estimate the pose parameters, such as translation, rotation, and overall scaling to achieve the linear alignment for iris matching. However, the nonlinear scaling in the angular direction is embedded in pupil dilation. Matching Score: After the termination of the PFM, the point correspondence between the ith feature point of an iris template and the jth feature point of a test image can be estimated as follows:

$$k_{ij} = \frac{(a\omega_{ij} + bt_{ij})}{(a+b)} \quad (8)$$

A – Log-Gabor filter

The Log-Gabor function, is a modification to the basic Gabor function, in that the frequency response is a Gaussian on a log frequency axis. The log-Gabor function has the advantage of the symmetry on the log frequency axis. The log axis, as pointed out is the optimum method for representing spatial frequency response of visual cortical neurons. The Log-Gabor filters spread information equally across the channels. On the contrary, ordinary Gabor filters over-represent low frequencies.

$$\log Gabor\left(\frac{1:ndata}{2+1}\right) = \frac{\exp\left(-\left(\frac{\log r}{WL}\right)^2\right)}{2\log \sigma^2} \quad (9)$$

B - Curvelet transform

It can detect curve boundaries better than log-gabor filters, wavelet and ridgelet transforms, or it can extract useful features that are missed in other transforms. The dimensionality of the iris image and improve the recognition rate, an iris features extraction method based on curvelet transform is proposed our curvelet-based iris features extraction method. Decompose images into set of sub-bands by the curvelet transform and automatic extraction of the most discriminative features of these sub-bands. Fig 3 shows the normalized image.

Fig. 3 – Normalized iris image

2.3 Iris Verification:

The Verification system is used to verify or reject the identity that a user claims. The receiver operation characteristic (ROC) curve, the equal error rate (EER), and the area under the ROC (AUC) are adopted to assess the performance in the verification scenario [17]. The iris pattern is usually occluded by the eyelid. A large occlusion area can affect the detection of the feature points and can result in information insufficiency. To evaluate the adverse effects of the occlusion, an additional experimental condition was used to reject the iris image occluded by the eyelid. Let the ration of the occluded area to the area of the complete iris pattern be defined as the occluded ratio. If the occluded ratio of an iris sample is larger than the rejection threshold T_0 ,this sample should be discarded.There are two major factors that decrease the performance of our iris recognition system. First, the significant deformation of iris texture around the pupil can result in a low genuine matching score. The second adverse factor is that part of the iris is occluded by the eyelid and eyelashes. In this situation, the number of detected local feature points is not sufficient to discriminate iris images from different classes.

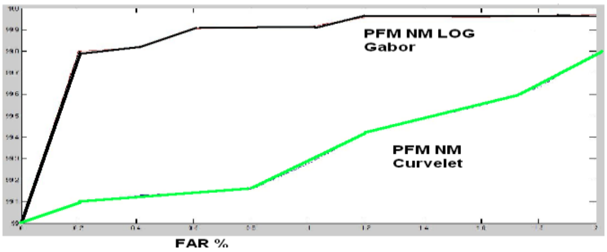


Fig. 4 – ROC curves of the PFM-NM Log Gabor filter , PFM-NM Curvelet

TABLE 1: THE ACCURACY ACHIEVED BY OUR PROPOSED METHOD

S.No.	Different Approachs	Accyracy (%)
1	Amir Azizi [12]	96.5
2	k.masoud [13]	95.9
3	A.T zaim [14]	95
4	Li Ma [15]	94.9
5	Vladan [16]	94.7
6	Hanho Sung [9]	94.54
7	Vladan [17]	94.3
8	Rober w.Ives [18]	93
9	Boles [19]	92.64
10	Hao Meng [20]	87.4
11	Agus Harjoko [21]	84.25
12	Mojtaba [30]	97.96
13	Mojtaba[30]	98
14	Log-Gabor, our method	99.49
15	Curvelet, our method	99.95

Table 1: Shows the accuracy achieved by our proposed method based on log-Gabor filter and Curvelet and other different methods for iris identification

3. CONCLUSION

A novel matching algorithm with invariant properties for iris recognition system based on the local feature points extracted by a bank of Log Gabor filters and Curvelet transform. The proposed matching algorithm, which is based on the PFM method, is used to compare two sets of feature points by using the information comprising the local features and the position of each point. A fuzzy curve detection method has been proposed to extract the inner and outer boundaries of the iris from a gray-level image. We compared the achieved accuracy with 13 different approaches. The accuracy percentage of curvelet transform is comparatively more than the log-Gabor filter. Hence using curvelet transform even is better than log-gabor filter and so gets more accuracy.

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