Iris Segmentation and Recognition System

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Abstract-- The richness and apparent stability of the iris texture make it a robust bio-metric trait for personal authentication. The performance of an automated iris recognition system is affected by the accuracy of the segmentation process used to localize the iris structure. In case of wrong segmentation, wrong features will be extracted and hence, may lead to false identification results. Most of the authors propose Circular Hough Transform to localize the boundary of IRIS. But the problem with this technique is its high consumption of time and memory. It also requires a precise estimated range of the boundary and it fails to localize the IRIS if the correct estimation is not provided. The proposed technique follows a basic strategy and obtains the major boundaries, by using canny edge detector. Features have been extracted using Curve lets Transform; Principal Component Analysis is then used to reduce the dimension of the features. Then SVM has been used as classifier. The implementation of recognition method has shown encouraging results.

Index Terms— Support Vector Machine (SVM), Recognition Method, Canny edge detector, Circular Hough Transform (CHT)

1. INTRODUCTION

The need of personal identification has Increase a lot during recent times. As bio-metric technique, iris recognition is getting preference over other methods and has drawn great attention of scientists because of uniqueness, non-invasiveness and stability of human iris patterns. So many commercial systems have been developed to treat the eye images and perform identification or verification procedures [10], since the first automatic iris recognition system was proposed by 1.G. Daugman in 1993 [9]. Daugman and Wildes' [1,2]approaches linger the most significant and distinguished among most of the recognized iris recognition systems. The use of different image acquisition and iris segmentation methods provides it some advantages in some aspects over Daugman system [I2].Almost all other techniques [3, 4, 5, 6] that have been proposed since were developed using the basic steps outlined in the pioneering work of Daugman and Wildes [10]. The original approach of Daugman initiated many of the new research advancements as well as commercial products [11,5].

A typical iris recognition procedure consists of four steps: (1) Normalization, (2) Segmentation (3) Feature extraction and (4) Classification. Figure. 1 shows the structure of human eye. Irrelevant parts such as pupil, sclera and eyelids are present along with the iris.

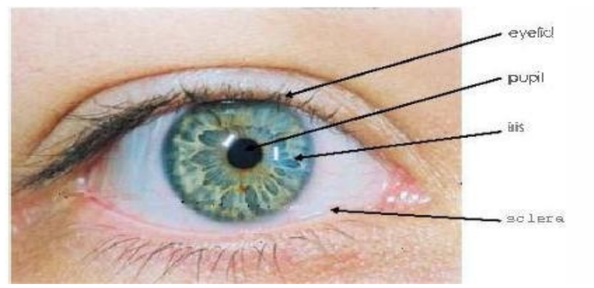

Figure I: Eye Image

The segmentation process digs out the iris portion from the eye image. An integro-differential operator was used by Daugman [9] to locate the inner and outer boundaries of the iris. Wildes [2] applied edge detection and then circular Hough transform (CHT) to find the circular iris portion. This segmentation method is widely applied in different iris recognition systems. Yu Chen [10] applied fast CHT and found the correct iris boundaries by performing CHT operation twice. Ma et al. [14] located the iris circle prior to apply edge detection and Hough transformation. It accelerated the computational speed by reducing the search space of Hough transform. Other iris segmentation techniques in [7, 13, 15] are almost similar to the approaches in [9, 2].

Normalization of isolated irises is carried out, in order to make the irises to the same dimension for processing and comparison. Daugman [9] represented the iris in pseudo-polar coordinate system. Registration of the input image with the model image using an affine transform model was proposed by Wildes [2]. Ma et al. [14] normalized the iris into an image of fixed size.

In this research, a simple method of segmentation is employed using Gaussian filter followed by canny edge detector after the necessary preprocessing. It gives the major edges of the eye from which iris boundary can easily be localized.
Feature extraction is then applied on the

ISSN: 2278 – 1323

Segmented images, to represent the iris in fewer dimensions. The use of Curve lets transform has been proposed for this phase. Support Vector Machine has been used for classification purpose.

II. PREPROCESSIONING AND NORMALIZATION

The iris images which are color images (Figure.2) acquired from the U POL database[8]. So these are converted to gray level in order to save the computational cost and storage memory. In normalization process, the 768 x 576 images were converted to 512 x 512 sized images. In order to perform this operation, the extra portion on left and right side of the obtained images is deleted and then image is resized to the desired resolution (Figure.2c).

Histogram Equalization was then applied to adjust the contrast of the image

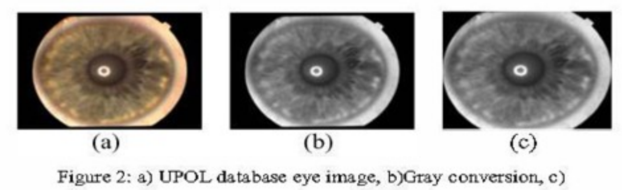

Figure 2: a) U POL database eye image, b)Gray conversion, c) Normalized image

III. SEGMENTATION

A segmentation method generally recommended by different researchers is to use Circular Hough Transform. It is a good method but takes a lot of time and memory for processing. Instead, a simple method to obtain the segmented iris images is to apply the Gaussian filter followed by canny In this technique Gaussian filter, with window size 30 and sigma = 5, is applied to the image. This results in a smoothed or blurred eye image. Figure.3a shows an eye image while Figure.3b shows the resultant image obtained by applying Gaussian Filter.

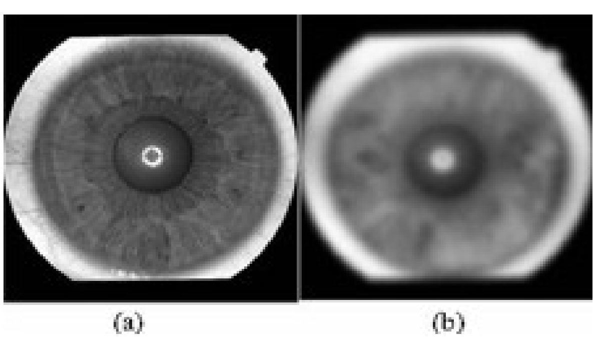

Figure 3: a) Gray image b)Blurred image

Canny edge detection technique is then applied to the obtained smoothed image. As a result we get the major boundaries/edges of the image (Figure. 4a). The biggest connected component in the obtained image is the outer boundary of the IRIS. A circle is then fit over that connected component to obtain the IRIS boundary. This process will give the outer boundary of the IRIS (Shown in Figure.4b). Hence it is termed as the outer segmentation. Once the IRIS boundary is known range of the pupil boundary could be calculated, which is always in some ratio with the IRIS boundary. Generally the IRIS and pupil range from: IRIS/Pupil >2 and IRIS/Pupil< 4

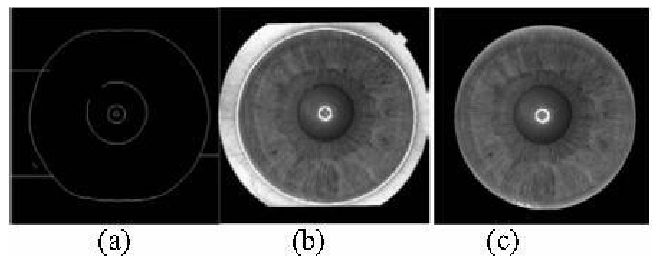

Figure 4: a) Boundary image b) Outer iris circle fitted, c) Outer Segmented Iris image

After outer boundary is detected, the image portion outside the boundary is deleted because it is not the part of IRIS and hence of no use for our system. Figure.4c shows an outer segmented image. To find the inner iris boundary, Canny edge detector is applied on outer segmented image. As explained earlier, iris and pupil have a radius ratio of 2. This is an experimental measure for U POL images and it may vary for other databases. So, take a circular mask of radius R = (Radius IRIS)/ 2. Delete all the part outside radius R (Figure. 5b). Now, scan the whole image for the longest connected component as shown in Figure. 5c). It will surely be the boundary of Pupil (Fig. 5d). Delete the whole image portion inside that boundary because pupil part is unwanted in our system. Hence the whole IRIS is segmented from the rest of the image. Figure. 5 show a fully segmented image. The technique works equally on both left and right eyes.

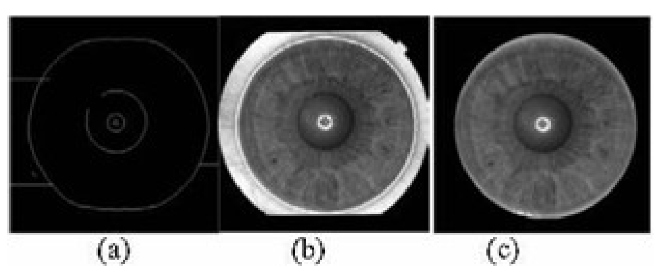

Figure 5: a) Edge image of Figure.5c, b) R=R mask applied, c) Longest connected component, d) Pupil localized, e) Segmented IRIS image

ISSN: 2278 – 1323

This is a very simple method and using this, large time and memory complexity of CHT could be avoided.

IV. FEATURE EXTRACTION AND CLASSIFICATION

Features extraction is generally considered the most significant step for any recognition system. As many researcher [16, 21, 22] used wavelet transform for feature extraction in lRIS recognition, so Curve lets transform being an extension of the wavelet concept, which is becoming popular in image processing and scientific computing, has been applied in this work. Curve lets coefficients are collected by various scales and angles. All these Curve lets coefficients are joined in a vector to form feature vector. Curve lets are proper foundations for representing images, where the curves have bounded curvature, i.e. where objects in the image have a minimum length scale. Cartoons, geometrical diagrams, and text contain this property. When such types of images are zoomed in, the edges they contain appear increasingly straight. Curve lets take advantage of this property, by defining the higher resolution Curve lets to be skinnier the lower resolution Curve lets [23].

Dimension Reduction: Curve lets Transform returns on average 28000 coefficients/features and we cannot pass such a large number of features directly to the classifier because of two reasons;

1) Due to such a large number of features, classification time and memory consumption will be increased. Many of the classifiers may not support such a large number of features.
2) Most of the coefficients may not have much diverse information of the image and hence can lead to wrong classification. To avoid these problems, we reduce the dimensional of the features and choose the best representational features for the images using Principal Component Analysis (PCA). Different number of features, ranging from 1-60, has been obtained from PCA for classification and the results have been discussed in the Performance Evaluation section.

The reduced feature sequence is extracted from the iris images using PCA technique is fed to train the support vector machine (SVM) as iris pattern classifiers. The parameters of SVM are tuned to improve the overall system performance. Optimal values for these parameters have been searched, using grid (looped hit and trial method) method, and are mentioned in the results Tables. In our case we have 64 subjects hence, 64 classes. For each eye, we have used two images for training while the third image for testing purpose.

V. HOUGH TRANSFORM

The circular Hough transform can be employed to deduce the radius and center coordinates of the pupil and iris regions. An automatic segmentation algorithm based on the circular Hough transform is employed.

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 center coordinates x_c and y_c, and the radius *r*, which are able to define any circle according to the equation

$$x_c^2 + y_c^2 - r^2 = 0$$

Canny edge detection is used to create an edge map, and only horizontal gradient information is taken. The linear Hough transform is implemented using the MATLAB transform, which is a form of the Hough transform. If the maximum in Hough space is lower than a set threshold, then no line is fitted, since this corresponds to non-occluding eyelids. Also, the lines are restricted to lie exterior to the pupil region, and interior to the iris region A linear Hough transform has the advantage over its version, in that there are less parameters to deduce, making the process less computationally demanding.

The algorithm of this method is elaborated as follows:

Step 1: Capture the same person's eye images under different lighting levels

Step 2: Measure the pupil diameter from the captured eye images. If these values are divergent then the image is actually from a real source (human), otherwise artificial sources may have been used. The diameter of the pupil is calculated by satisfying (1). Equations (2) and (3) describe the challenge-response process.

$$(x - x_1)(x - x_2) + (y - y_1)(y - y_2) = 0,$$

$$T_d = \sum_{i=0}^{n-1} |\Phi_i - \Phi_{i+1}|,$$

$$CRT = \begin{cases} \text{True}, & \text{if } T_d \neq 0, \\ \text{False}, & \text{otherwise} \end{cases}$$

ISSN: 2278 – 1323

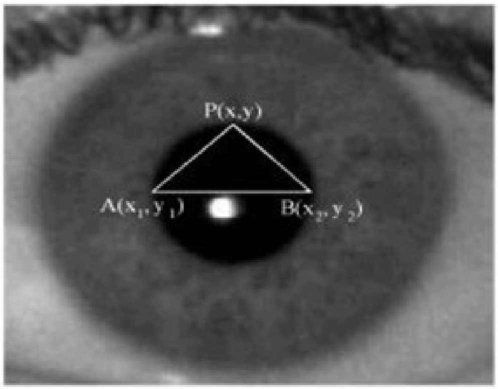

Figure 6: Measurement of diameter of the Pupil Boundary.

Where *Td* is total diameter of the pupil in the capturing sequences, CRT is a challenge-response test parameter, *n* is number of eye images, _*i* and _*i*+1 are diameters of the pupil under different illuminations.

This method assures that an input is coming from a real sequence and not from photographs or other artificial sources. The biometrics-capturing device needs to be capable of ensuring that they are inspecting genuine user features (as opposed to a photograph or recording) and that the output signal is not substituted. This is used to prevent replay attacks lifted from Video-signals, for instance by connecting a video recorder to the frame-grabber. 57.7% - false non-matches due to the occlusion by Eyelids/eyelashes in recognition.

2. Identical twins have the same DNA making up their tissue structure, they have different iris patterns.

Twilight – sunset, evening light
Phony - Fake, not genuine
Constricted - contracted, thin
Dilate - Open, Expand

VI . RESULTS AND DISCUSSIONS

As mentioned earlier, the iris images used in this research work are acquired from the U POL database [8]. The advantage of this database over other databases is its high quality images. The edges of the images and the IRIS patterns are clearly visible in the images. This database contains 64 distinctive subjects with each set containing three sample images for both eyes. These images were captured through an optical device i.e. TOP CON TRC501A, which is attached with a digital camera i.e. SONY DXC-950P 3CCD. The format of captured images is 24-bit PNG and the resolution of each image is 768 x 576 pixels. So all the images were normalized to 512 x 512 dimensions. Segmentation method discussed in section III was applied to 384 UPOL database images and the results were obtained. By varying sigma value in the Gaussian filter, different results have been obtained. The results are summarized in the Table I.As shown in Table I, the best results have been observed by smoothing out the image using Gaussian spread (Sigma) equal to 5 and then detecting the edges and estimating the IRIS in the image. The proposed technique is also very efficient in terms of time consumption. The time complexity of the technique is given in Table 2.

TABLE 2. GAUSSIAN-CANNY BASED SEGMENTATION USING DIFFERENT SIGMA VALUES

Sigma	Segmentation Accuracy (%)
4.0	89.58 %
5.0	100.0 %
6.0	97.92 %

VII. CONCLUSION

In this research work an attempt is made to develop a simple and efficient method for iris recognition using simple segmentation method. Using 20 or more Curve lets coefficients, obtained from histogram equalized (Left side) eye images of UPOL database, can give up to 100 % accuracy of the recognition system. The time consumption of the system is also very low, as it can identify an IRIS within 4 seconds. This time includes segmentation, feature extraction, feature selection /dimension reduction and classification time. After the successful experiments and the encouraging results achieved, it can be claimed that the proposed system is capable of fast and efficient iris identification. In the proposed system, UPOL database have been used for IRIS images. The system could be extended to other databases e.g. CASIA Database. Moreover, average time consumption of the system could be improved by changing / improving the segmentation technique and other classifiers may also be used to evaluate the system.

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ISSN: 2278 – 1323