Iris Recognition using Cumulative Sums based Approach and DCT

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ABSTRACT

Unlike the other biometrics such as fingerprints and face, distinct aspect of iris comes from randomly distributed features. This leads to its high reliability for personal identification. At the same time it is difficult to represent the details in an image. In this paper iris recognition algorithm using cumulative based sums and DCT is implemented. The results using these two methods have been compared.

General Terms

Iris Recognition, DCT, Security, Algorithms et. al.

Keywords

Biometrics, iris recognition, iris code generation, Fourier Transform, Discrete Cosine transform, Image compression.

1. INTRODUCTION

1.1 Motivation: In fact, according to the most Recent National Institute of Research Report on Entry-control Technologies, retina or iris pattern scanners are considered the most accurate of all biometric devices. An important use of iris detection systems is in immigration security. The U.S.Government and the INS are exploring various iris identification programs for use by border control facilities. Another system that will very likely become standard procedure for tracking immigrants is the use of a smart card or ID card like the one used for airport security where the immigrant's iris code along with other also has very creditable prospects in the terrorist- tracking industry. Many government officials including U.S.Senator Dianne Einstein feel that if this type of tracking system were in place before 11 September 2001, the terrorist attack could have potentially been prevented. Hence, the research in this area became challenging in today's world.

1.1 What is Iris?

Iris image as shown in Figure.1 is a protected internal organ of the eye, located behind the chorea and the aqueous humor. The iris is perforated close to its centre by a circular aperture known as pupil. The function of iris is to control the amount of light entering through the pupil, and this is done by the sphincter and the dilator muscles, which adjust the size of pupil. The average diameter of iris is 12 mm, and the pupil size can vary from 10% to 80% of the iris diameter. Formation of iris begins during the third month of embryonic life. The unique pattern on the surface of iris is formed during the first year of life, and pigmentation of stoma takes place for the first few years. Formation of unique pattern of iris is random and not related to any generic factors. biometric information is stored on the card. This is the technology that has very creditable prospects in the terrorist- tracking industry. Many government officials including U.S.Senator Dianne Einstein feel that if this type of tracking system were in place before 11 September 2001, the terrorist attack could have potentially been prevented. Hence, the research in this area became challenging in today's world.

1.3. Related work: Research into iris recognition technology has stated since 1935. It was during that year an article appeared in the New York State Journal of Medicine that suggested that the pattern of blood vessels on the retina could be used to identify an individual. Since 1935, extensive research and development has gone into establishing iris and retinal patterns and the uniqueness of them. The development of the actual iris scanning technology is credited to Dr. John Daugman. He is the man responsible for the creation of the mathematical (algorithms) formulae used to measure the varying characteristics of one's iris. These mathematical formulae were patented by him at Cambridge University in 1994 [1,2]..The rest of this paper is organized as follows: Section 2 briefly summarizes about iris details. Iris recognition system and feature extraction method using cumulative sums based approach have been described in Section 3. Section 4 covers iris recognition with image compression using DCT. Section 5 covers conclusion and future scope.

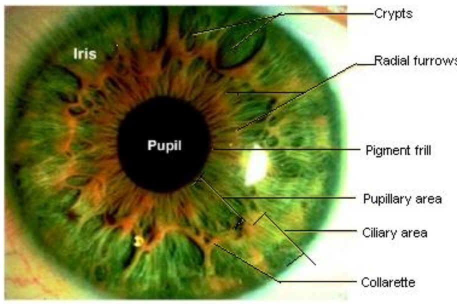

Figure.1.Iris Image

Advantages of the Iris for Identification: (1) It is highly protected, internal organ of the eye. (2) It is externally visible pattern imaged from a distance. (3) Iris patterns possess a high degree of randomness. (4) Its Entropy is 3.2 bits per square-millimeter (5) It has unique feature so used in personal identification (6) Iris patterns are apparently stable throughout life.(7) Image analysis and encoding time is 1 second. (8) Search speed of iris codes 100,000 Iris Codes per second on 300MHz CPU. *Disadvantages of the Iris for Identification***:** (1) It is a Small target to acquire from a distance (1m). (2) It is partially occluded by eyelids, often drooping. (3) It deforms non-elastically as pupil changes size. (4) Illumination should not be visible or bright. (5) It has some negative (Orwell Ian) connotations.

2. IRIS RECOGNITION SYSTEM

Iris Recognition System is a robust method of a personal identification since the iris pattern is unique and remains unchanged throughout one's life. Also it has various advantages like greater speed, simplicity and accuracy. It consists of major four steps. Image acquisition, Iris preprocessing, Normalization, Feature extraction and verification.

2.1 Iris image acquisition: Image acquisition is necessary to capture a sequence of iris images from the subject using a specifically designed sensor. Hence one of the important major challenges is to capture high quality images. In designing an image acquisition system.Aspects like the lighting system, the positioning system, and the physical capture system [3] is to be considered. Normally images are captured by high resolution CCD camera from distances up to about 3 feet (one meter). Most of the work has been done on iris Image acquisition that has made noninvasive imaging at a distance possible.

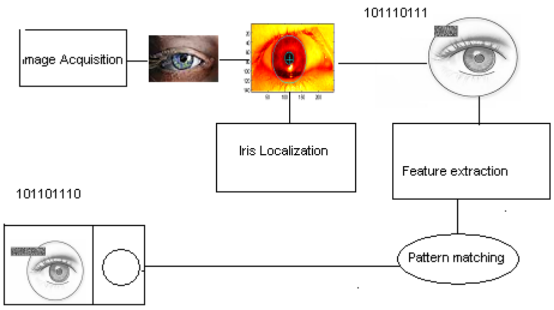

Figure.2. Block diagram Iris Recognition System

2.2 Iris preprocessing: To get an iris free of noise, independent of illumination and size one has to detect Iris pupil and Iris circle.

Iris Pupil Detection: First read the image for database. Using region of interest according to color, we can detect the pupil but we must know the threshold value of pupil intensity.To find the threshold value of pupil intensity, take the histogram of original image, which gives graphical representation between numbers of pixels vs pixel intensity. As the pupil is black in color, the pupil pixel intensity lies closer to zero. Pupil has moderate size. Determine maximum number of pixels for intensity value, which is closer to zero. That value is threshold value of pupil intensity.

Steps to find radius of pupil: Locate four points on pupil circumference,Find out co-ordinates of four points (top, bottom, left, right) , Find centre co-ordinates.

After the first step results we have the image with only pupil. That is now our aim to find out the center of the pupil so that the iris can be localized. We first find out the four points (top, bottom, left and right) for localizing the pupil center Figure 3.4 shows the pupil image with four points detection. The image is magnified and the points are painted with larger dots so as to have clear understanding. After finding the co-ordinates of these points the x-coordinate of center pixel can be approximated by x-coordinates of left and right pixels. The y-coordinate of the center pixel can be approximated by y- coordinates of top and bottom pixels. After finding out the center pixel coordinates we can easily find out the radius of the pupil.

Fig. 3 Pupil image with four points (top, bottom, and right,

After localizing the pupil, the center of pupil is determined and accordingly the radius is also calculated. Mathematical calculations for determining the radius is shown below.

- rad1= abs (right y- center y);
- rad2 = abs (center y-left y);
- rad3 = abs (bottom x- center x);
- rad4 =abs (center x- top x);
- rad array =[rad1 rad2 rad3 rad4];
- Radius = max (rad array);
- To develop this system we consider iris radius=pupil radius+38.

2.3. Normalization: Once the iris region is successfully segmented from an eye image, the next stage is to transform the iris region so that it has fixed dimentions in order to allow comparisons. 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 sources of inconsistency include, varying imaging distance, rotation of the camera, head tilt, and rotation of the eye within the eye socket. The normalization process will produce iris regions that 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. Iris Image in Cartesian coordinates is transformed to polar coordinates using following transformation:

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

$$x(r,\theta) = (r_{inner} + r * r_{gap}).Cos\theta - (3)$$

$$y(r,\theta) = (r_{inner} + r * r_{gap}).\sin\theta - (4)$$

The value of r varies between 0 and 1which make sure that all iris images will be normalized to same size. r is calculated using radial resolution which is number of pixel taken between iris circle and pupillary circle. As pupil and iris circle are not concentric circles, the value or r_{gap} is calculated from horizontal and vertical differences between pupil and iris circles [5].

2.4 Feature extraction and matching:

In order to provide accurate recognition of individuals, the most discriminating information present in an iris pattern must be extracted. Only the significant features of iris must be encoded so that comparisons between templates can be made. Most iris recognition system makes use of a band pass decomposition of iris image to create a biometric template.

The template that is generated in the feature encoding process will also need a corresponding matching metric, which gives a measure of similarity between two iris templates. This metric should give one range of values when comparing templates generated from same eye, known as inter-class comparisons, and another range of values when comparing templates created from different irises, known as inter-class comparisons. These two cases should give distinct and separate values, so that a decision can be made with high confidence as to whether two templates are from the same iris, or from two different irises.

2.4.1.Cumulative sums-Based Change Analysis:

The feature extraction in this thesis is implemented with the method cumulative sum based change in gray values analysis. Cumulative sums are calculated by addition and subtraction, so the cumulative sums based feature extraction method creates a lower processing burden than other methods. Since cumulative sums S_i are calculated by adding the difference between the current value and average to the previous sums:

$$S_i = S_{i-1} + (X_i - \overline{X})$$

Fig 4 shows how the normalized iris part is divided in to number of groups horizontally and vertically to reduce the computation time.

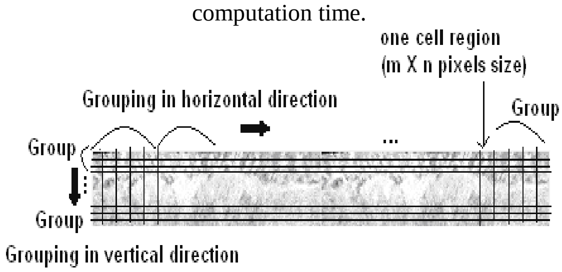

Fig.4 Division of normalized iris image into cell and grouping of cell region

Features are extracted [Horizontally] as follows:

Step i. Fixed out the dimension of the normalized image.

Step ii. Divide normalized iris image into basic cell region. One cell region equals to 3(row) X 10 (column) pixel size.

Step iii. Represent each cell by their average grey value as a representative of respective cell.

Step iv. Make the group of average values obtained [1X5].

Step v. Calculate cumulative sums over each group.

Features are extracted [Vertically] as follows:

Step i. Take the transpose of normalized image matrix which becomes 150(rows) X 36(columns) pixel size.

Step ii. Make the group of average values obtained [X3].

Step iii. Calculate cumulative sums over each group.

This will gives the two matrixes in which each element indicates cumulative sum value. For horizontal process 12 X 15 and for vertical process 15 X 12 matrixes will obtain. The procedure to calculate cumulative sum is described as follows- suppose that X1,X2,X3,X4,X5 are five representative values of each cell region within the first group located on the left top corner of fig.5.1.

Further the average sum is

$$\overline{x} = (x1 + x2 + x3 + x4 + x5)/5$$

Current value and the average to the previous sum:

$$S_i = S_{i-1} + (X_i - \overline{X}) \quad for\ i = 1,2,3,4,5.$$

Radial and Circular Feature Encoding:

This approach is based on edge detection .Edges are detected in input image using canny edge detector. After edge detection image is changed to binary format in which white pixels are present on edges and black pixels elsewhere. The number of white pixels in radial direction and on circle of different radius gives important information about iris patterns. Features from normalized images are extracted in two ways – (a) radial way (b) circular way.

(a) Radial features

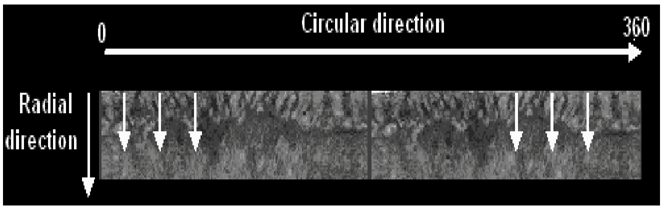

Fig.5 Feature extraction in radial direction

In iris image value of radial feature at particular angle will be number of white pixels along the radial direction.

If

$$S_{r,\theta} = 1 \ iris\_polar\_image[r][\theta] == WHITE$$
$$= 0 \ iris\_polar\_image[r][\theta] == BLACK$$

Feature at angle θ will be

$$F_\theta = \sum_{r=1}^{N} S_{r,\theta}$$

(b) Circular features

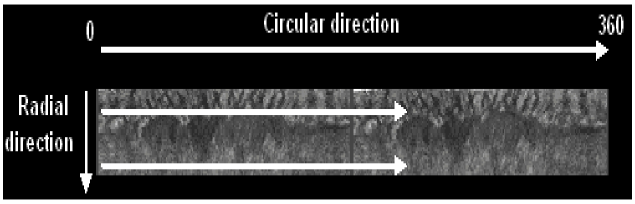

Fig..6 Feature extraction in rcular direction

In iris image value of circular feature at particular radius ill be considered as sum of white pixels along the circle of that radius. Keeping the meaning of $S_{r,\theta}$ same .the feature of particular radius r will be given as following.

$$F_r = \sum_{\theta=0}^{2\pi} S_{r,\theta}$$

Iris code will be considered as sequence of radial and circular features. In this method number of white pixel on radial and circular direction is measured which then indicates code for that particular eye image. It is obtained by following steps.

i..Image in polar form is converted into binary form ii..Number of white pixels in radial and circular direction is measured.

White pixels [counts] = 1059

Black pixels [x] = 7041

iii.Total numbers of white pixels are stored.

iv.Similar steps from 1 to 3 are followed for both the query and data base image.

v.For matching compare the two images by using subtraction of white pixels available in database image from number of white pixels available in query image.

2.4.2 Iris recognition with normalized image compression:

The algorithm mentioned above is implemented for normalized image. In the JPEG image compression algorithm, the input image is divided into 8-by-8 or 16-by-16 blocks, and the two-dimensional DCT is computed for each block. The DCT coefficients are then quantized, coded, and transmitted. The JPEG receiver (or JPEG file reader) decodes the quantized DCT coefficients, computes the inverse two-dimensional DCT of each block, and then puts the blocks back together into a single image. For typical images, many of the DCT coefficients have values close to zero; these coefficients can be discarded without seriously affecting the quality of the reconstructed image. The example code below computes the two-dimensional DCT of 8-by-8 blocks in the input image, discards (sets to zero) all but 10 of the 64 DCT coefficients in each block, and then reconstructs the image using the two-dimensional inverse DCT of each block.

2.5 Verification and matching

In order to provide accurate recognition of individuals, the most discriminating information present in an iris pattern must be extracted. Only the significant features of the iris must be encoded so that comparisons between templates can be made.

The template that is generated in the feature encoding process will also need a corresponding matching metric, which gives a measure of similarity between two iris templates. This metric should give one range of values when comparing templates generated from the same eye, known as intra-class comparisons, and another range of values when comparing templates created from different irises, known as inter-class comparisons. These two cases should give distinct and separate values, so that a decision can be made with high confidence as to whether two templates are from the same iris, or from two different irises. The three metrics that I used in this thesis are explained in brief below.

i. Hamming Distance (HD)

ii. Fuzzy Hamming Distance (FHD)

iii. The Euclidean Distance (ED)

The Hamming Distance gives a measure of how many bits are the same between two bit patterns. Using the 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.

In comparing the bit patterns X and Y, the hamming distance, HD, is defined as the sum of disagreeing bits (sum of the exclusive-OR between X and Y) over N, the total number of the bit pattern.

$$HD=\frac{1}{N}\sum_{j=1}^{N} x_j\ (XOR)\ y_j$$

Since an individual iris region contains features with high degrees of freedom , each iris region will produce a bit pattern which is independent to that produced by another iris , on the other hand , two iris codes produced from the same iris will be highly correlated.

If two bits patterns are completely independent, such as iris templates generated from different irises, the hamming distance between the two patterns should equal 0.5. This occurs because independence implies the two bit patterns will be totally random, so there is 0.5 chance of setting any bit to 1, and vice versa. Therefore, half of the bits will agree and half will disagree between the two patterns. If two patterns are derived from the same iris, the hamming distance between them will be close to 0.0, since they are highly correlated and the bits should agree between the two iris codes.

Although the Hamming distance has several applications, the main concern is the assumption that every bit is independent of its neighbors. In other words, it assumes no local correlation. The Fuzzy Hamming Distance (FHD) also measures dissimilarity between bit strings of equal length. However, it is not simply the number of 1s in the result of an XOR operation. The FHD incorporates bit locality. The value of Hamming distances is limited by the fact that it counts only exact matches, whereas in various applications, corresponding bits that are close by, but not exactly matched, can still be considered to be almost identical. We here define a "fuzzy Hamming distance" that extends the Hamming concept to give partial credit for near misses, and suggest a dynamic programming algorithm that permits it to be computed efficiently. The draw back of conventional hamming distance is that it measures absolute differences in bit without giving or indicating credits for 'close calls'.

$$FHD=\frac{1}{N}\sum_{i=1}^{N}\left|x_i-y_i\right|$$

The Euclidean Distance (ED) can be used to compare two templates, especially if the template is composed of integer values. The weighting Euclidean distance gives a measure of how similar a collection of values are between two templates. The Euclidean distance metric is a classically used means of measuring the distance between 2 vectors of n elements.Euclidean distance is especially useful for comparing matching whole word object elements of two vectors. The most commonly used metric for matching the two bit strings generated by query image and template stored in database is the Hamming Distance. It is a simple XOR operation where result equal to zero when both said a string has same bit string.

Although the Hamming distance has several applications, the main concern is the assumption that every bit is independent of its neighbors. In other words, it assumes no local correlation. A fuzzy hamming distance; a new metric is introduced to better deal with bit string patterns which may be locally-correlated. Euclidean distance is especially useful for comparing matching whole word object elements of two vectors. It measures only distance between two iris code vectors.

$$ED = \sqrt{\sum_{i=1}^{N} (x_i - y_i)^2}$$

Table.1 gives FAR and FRR according to hamming distance and DCT. DCT performs better compared with cumulative sums based approach.

3. RESULTS and CONCLUSIONS:

FAR and FRR according to hamming distance is calculated as follows.

$$FAR = \frac{Number\ of\ times\ different\ person\ matched \times 100}{Number\ of\ comparision\ between\ different\ persons}$$

False Rejecting Rate:-The fraction of the number of rejected client patterns divided by the total number of client patterns is called False Rejection Rate (FRR).

$$FRR = \frac{Number\ of\ times\ same\ person\ rejected \times 100}{Number\ of\ comparision\ between\ same\ person}$$

The over all accuracy of algorithm is defined as

$$Accuracy = 100 - \frac{FRR + FAR}{2}$$

Table1.

Sr.No.	Method	FAR%	FRR%
1	Using cumulative sums based approach	12.5	13.33
2	Using DCT based approach	11.75	10.25

Calculation of accuracy for Ist algorithm is 87.6% and for IInd method it is 89%. Hence DCT performs better in iris recognition compared to cumulative sums approach.

4. FUTURE SCOPE:

The above implementation is carried out for CASIA data bases of various versions.I It is required to work with all available data bases and with nonco-operative iris images. It is also required to develop embedded system with iris recognition

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