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Iris Recognition Systemby using Discrete cosine Transform

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Abstract- Iris recognition system is the biometric identification system. Iris has an intricate structure, uniqueness, stability, natural protection. Due to this features of the iris it can be used for biometric identification. This system gives better performance than other biometric identification systems. A novel eyelash removal method for preprocessing of human iris images in a human iris recognition system is presented.. Discrete cosine transform (DCT) method is used for feature extraction. For matching of two iris code Hamming distance calculation is used. EER value must be less for the optimum performance of the system.
Keywords - Biometrics, iris recognition, image preprocessing, Eyelash removal, Feature extraction, Discrete cosine transform, Hamming distance.

I. INTRODUCTION:

Iris recognition technology is a biometric identification system capable of positively recognizing individuals without physical contact or human decision-making. Personal identification has historically been based on what a person possesses (a card); knows (a Personal Identification Number, or PIN); or is (an inherent physiological or behavioral characteristic). Facial features (both infrared signatures and geometry), fingerprints, hand geometry, vein patterns, retinal patterns, voice patterns, and signature dynamics have all been explored as biometric identifiers with varying levels of success. All but voice and facial identification require contact or have been characterized by some as invasive or intrusive in some other way. Many have suffered from high cost and unsatisfactory error rates.

This new technology, using the unique patterns of the human iris, overcomes previous shortcomings and provides positive recognition of an individual without contact or invasion, at extremely high confidence levels. The video-based system locates the eye and iris, evaluates the degree of occlusion by eyelid and specular reflection, determines the quality of image focus, and determines the center and boundary of the pupil and the limbus (outer edge of the iris) for processing. The features of the iris are then measured and encoded into a 512 byte Iris Code record for enrollment or recognition.

II. BACKGROUND

- Iris Anatomy

The human iris, a thin circular diaphragm lying between the cornea and the lens, has an intricate structure with many minute characteristics such as furrows, freckles, crypts, and coronas. Various parts of the human eye is shown in Fig 1. For every subject, these characteristics are unique. Apart from general textural appearance and color the finely detailed structure of an iris is not genetically determined but develops by a random process. The iris patterns of the two eyes of an individual or those of identical twins are completely independent and uncorrelated.

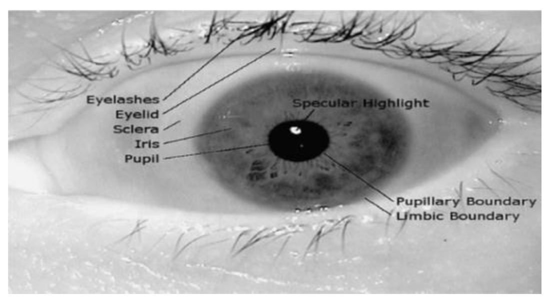

Fig.1 (a) human iris.

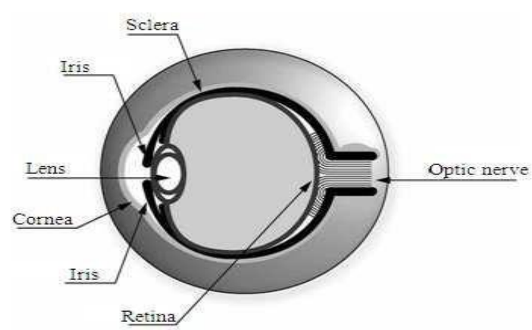

Fig.1 (b) Cross-sectional view of human iris.

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- Basis of the iris technology:

(a) Features of the Iris: The human iris is rich in features which can be used to quantitatively and positively distinguish one eye from another. The iris contains many collagenous fibers, contraction furrows, coronas, crypts, color, serpentine vasculature, striations, freckles, rifts, and pits. Measuring the patterns of these features and their spatial relationships to each other provides other quantifiable parameters useful to the identification process.
(b) Uniqueness of the Iris: The iris is unique because of the chaotic morphogenesis of that organ. Even identical twins have uncorrelated iris minutiae.
(c) Stability of the Iris: Notwithstanding its delicate nature, the iris is protected behind eyelid, cornea, aqueous humor, and frequently eyeglasses or contact lenses (which havenegligible effect on the recognition process). An iris is not normally contaminated with foreign material, and human instinct being what it is, the iris, or eye, is one of the most carefully protected organs in one's body
(d) Natural Protection: The human eye has a natural protection by means of eyelid and eyelashes. Due to this physiological property ,there is less possibility of iris damage. Hence, iris images can be used for biometric identification**.**

III. ALGORITHM

A typical iris recognition system includes iris capture, image pre-processing, feature extraction and matching. The performance of a system is greatly influenced by the quality of captured images. Amongst the various factors that could affect the quality of iris images, one of the most commonly encountered is eyelash occlusion, which can degrade iris images either during enrolment or verification. Examples of iris images with eyelash occlusion are shown in Figure 2.

Fig 2. Iris images occluded by eyelashes.

Such strong 'eyelash textures' obscure the real iris texture, and hence interfere seriously with the recognition capability of any recognition system. Reducing the influence of the eyelash on recognition is therefore an important problem. Early efforts to mitigate the effects of eyelash tried to ignore parts of the iris to avoid eyelash contamination. Later some researchers tried to detect and mask the eyelash pixels from the image. In this paper, eyelashes classified into two categories, separable and multiple. They then used an edge detector to find separable eyelashes, and recognized multiple eyelashes by intensity variance. This method removes eyelashes and restores the underlying iris texture as much as possible. Iris pixels occluded by eyelashes are recreated using information from their non-occluded neighbors.

The efficient discrete cosine transform (DCT) method is used for feature extraction. The DCT of a series of averaged overlapping angular patches are taken from normalized iris images and a small subset of coefficients is used to form sub feature vectors. Iris codes are generated as a sequence of many such sub features, and classification is carried out using a weighted Hamming distance metric. System parameters are optimized to give lowest equal error rates (EER) on two data sets.

The preferred metric for iris recognition performance is the Equal Error Rate (EER), which is the False Acceptance Rate (FAR) and False Rejection Rate (FRR) where they become equal. This **EER** is a single number often quoted from the **Receiver operating characteristic (**ROC) curve. ROC plot is the false reject rate on the Y axis and the false accept rate on the X axis.

A. Image Acquisition (Data Collection)

Two largest publicly available iris image data sets, are CASIA database and Bath database. CASIA database contains 2,156 images of 308 eyes and Bath database contains 2,955 images of 150 eyes. Images of the human iris obtained with Near-Infrared (NIR) lighting are necessary to reveal complex textures for darkly pigmented irises, while lighter irises can be imaged either in the infrared or visible spectrum . In collecting the Bath database, eyes are imaged using an NIR sensitive high-resolution (1,280 x 1,024) machine-vision camera with infrared lighting whose spectrum peaks around 820 nm. Daylight cut-off filters are used to eliminate reflections due to ambient visible light and care is taken to focus on the iris rather than on any other part of the eye such as eyelids or eyelashes.

With the subject sitting and positioned against chin and forehead rests, the camera is manually positioned. A focal length of 35mm, with the lens 20cm from the eye, ensures that a large proportion of the image is that of the iris. The incoherent NIR light source is an array of LEDs close to the camera lens so that its reflections are within the boundary of the pupil with the subject looking into the lens. To avoid thermal injury, the power of infrared radiation in the range of 780 nm to 3 um should be limited to less than 10 mW/cm2 according to US recommendations .A more stringent regulation for lasers (coherent light), widely followed in Europe, suggests a more conservative 0.77mW/cm2. Due to the presence of ambient visible lighting the pupil is partly constricted, thereby providing an additional safety mechanism.

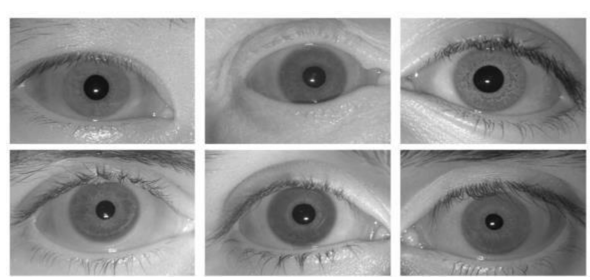


Fig. 3(a): Images from Bath database.

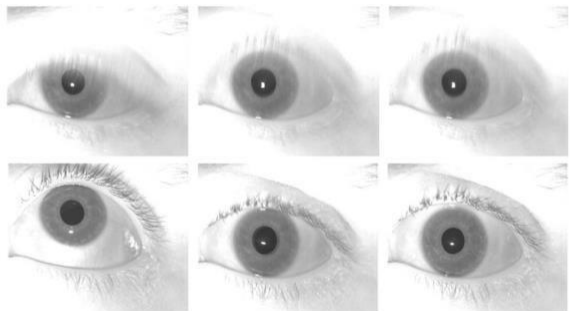


Fig 3(b) Images taken from a video-sequence of an eye illustrating the variations in the size of the reflected light source.

B. Image Preprocessing

For coding, irises are extracted from the eye images and normalized to a standard format for feature extraction in order to remove variability introduced by pupil dilation, camera-to-eye distance, head tilt, and torsional eye rotation within its socket. Moreover, images acquired by different cameras under different environmental conditions have different resolution and illumination distributions. All these factors need to be taken into consideration and compensated for in order to generate a final normalized version compliant with the feature extraction input format. The image preprocessing contain two main steps i.e. iris localization and iris normalization and enhancement. These two steps can be described as follows.

1. Localization: Location of the pupil and outer iris boundaries starts with the removal of the bright spot in the pupil caused by the reflection of the infrared light source. This reduces the influence of high gray-level values on the gray-scale distribution. Then, the image is scanned to isolate a region containing the pupil and iris. This is done by a heuristic method based on the assumption that the majority of image rows and columns passing through the pupil will have larger gray-level variance than those not passing through the pupil. It is assumed that the pupil is circular and, because the pupil boundary is a distinct edge feature, a Hough transform is used to find the center and radius of the pupil. To locate the outer boundary of the iris (limbus), a horizontal line through the pupil center is scanned for the jumps in gray level on either side of the pupil. The limbus is normally circular but its center does not necessarily coincide with that of the pupil. Hence pupil centre is shifted to image centre.

2. Normalization and Enhancement: Due to the dilation and constriction of the human pupil, the radial size of the iris varies under different illumination conditions and in response to physiological factors. The resulting deformation of the iris texture can be approximated as a linear deformation. Since we know the iris boundaries, we can map a rectangular image array back to an angular and radial position in the iris. This position will not, in general, map exactly onto a pixel in the source image, so the normalized gray value is obtained by bilinear interpolation from its four nearest neighbors. Finally, the gray levels are adjusted by removing the peak illumination caused by light sources reflecting from the eye, estimating and subtracting the slowly varying background illumination, and equalizing the gray-level histogram of the iris image. The final normalized image is of resolution 512x80, from which we code only the 48 rows nearest the pupil to mitigate the effect of eyelids.

3. Eyelash Removing: Eyelash removal algorithm based on nonlinear conditional directional filtering. Steps are as follows

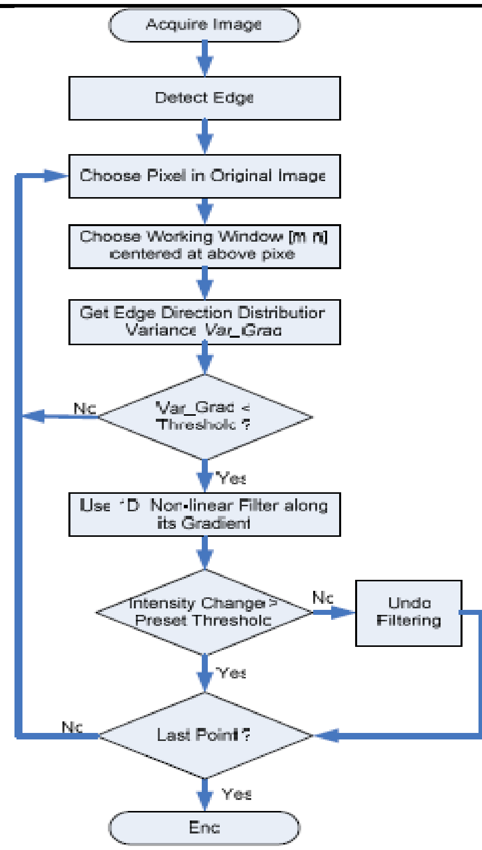


Fig.4 Flowchart for eyelash removing

➢ Edge Detection

An eyelash causes a discontinuity along its edges, so to detect an eyelash and estimate its direction, a 3 x 3 Sobel edge filter is applied to the normalized image, Figure 5.

(a)

-1	-2	-1
0	0	0
1	2	1

(b)

z_1	z_2	z_3
z_4	z_5	z_6
z_7	z_8	z_9

(c)

-1	0	1
-2	0	2
-1	0	1

Fig. 5 Sobel Edge Filter (a) X Derivative (b) Image Region (c) Y Derivative

For every pixel, the estimated gradients in the X and Y directions are [Gx ,Gy] and the magnitude of the gradient at the center point of the mask, called Grad, are computed:

$$G_x = (z_7 + 2z_8 + z_9) - (z_1 + 2z_2 + z_3)$$
$$G_y = (z_3 + 2z_6 + z_9) - (z_1 + 2z_4 + z_7)$$
$$Grad = \left(G_x^2 + G_y^2\right)^{1/2}$$

The local gradient direction (perpendicular to the edge) is:

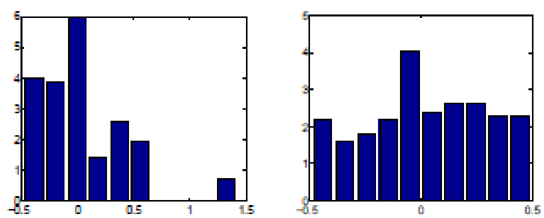
θ = arctan(Gy Gx)

- Eyelash Area Decision

To decide if a pixel is occluded, we define a window of size [m n] centered at the pixel and compute a gradient direction variance over those r pixels for which Grad > 15:

$$Var\_Grad = \frac{1}{r-1}\sum_{i=1}^{r}\left(\theta_i - \overline{\theta}\right)^2$$

If the gradient direction has a small variance, a strong edge is indicated, as can be seen in Figure 6, and this pixel is classified as being affected by eyelash.



(a) (b)

Fig. 6. Gradient Direction Distribution(a) Eyelash Area (b) Non-eyelash Area

- Non-linear Filtering

For each pixel classified as an eyelash pixel, a 1D median filter of length L is applied along the direction θ , to estimate the value of the image with the eyelash removed. In general the direction does not pass exactly through pixels, so the median filter is applied to values equally spaced by the distance between actual pixels, which are calculated using bilinear interpolation of the four nearest pixels. Not every pixel in the eyelash window is occluded by eyelash, so we only change the intensity if the intensity difference exceeds a threshold related to the total variance of the image.

$$Recover = Diff - k * Var(Image)$$

Diff is the difference in intensity between the filtered and unfiltered pixel and Var(Image) is the intensity variance of the whole (unfiltered) image. K is the parameter used to tune the threshold. If Recover is positive, the pixel is replaced by the filtered value, otherwise the filter is not applied.

- Visual Results

Figures 7 and 8 show the effect of the eyelash removal method on normalized human iris images with and without filtering. It is seen that visually the filter has little effect on an image with no eyelid occlusion, while in the occluded case the eyelashes are replaced by pixels representative of underlying iris texture. It is not perfect; the positions of the eyelashes are visible.

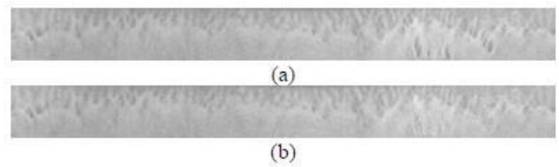


Fig.7(a) Image without eyelash occlusion; (b) The effect of the eyelash removal filter.

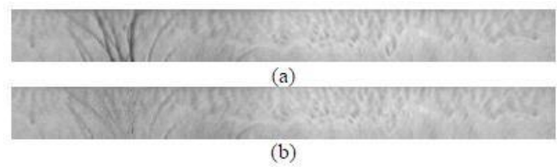


Fig.8 (a) Image affected by eyelash; (b) The effect ofthe eyelash removal filter.

C. Feature Extraction:

1. The Discrete Cosine Transform (DCT): A **discrete cosine transform** (**DCT**) expresses a sequence of finitely many data points in terms of a sum of cosine functions oscillating at different frequencies.

The DCT is a real valued transform, which calculates a truncated Chebyshev series possessing well-known minimax properties and can be implemented using the Discrete Fourier Transform (DFT). There are several variants but the one most commonly used operates on a real sequence Xn of length N to produce coefficients Ck,:

$$C_k = \frac{2}{N} w(k) \sum_{n=0}^{N-1} x_n \cos\left(\frac{2n+1}{2N}\pi k\right)$$

Where 0 ≤ k ≤ N-1

And

$$x_n = \sum_{k=0}^{N-1} w(k) C_k \cos\left(\frac{2n+1}{2N}\pi k\right)$$

Where 0 ≤ n ≤ N-1

And

W(k) = 1/√2 , k =0 and w(k) = 1, 1 ≤ k ≤ N-1

Due to its strong energy compaction property, the DCT is widely used for data compression.

2.Generating Feature vector : The feature vectors will be derived from the zero crossings of the differences between 1D DCT coefficients calculated in rectangular image patches, as illustrated by fig 9. Averaging across the width of these patches with appropriate windowing helps to smooth the data and mitigate the effects of noise and other image artifacts, as shown in fig 10. 1D DCT is used to code each patch along its length, giving low-computational cost.

Overlapping patches gave the best EER in combination with the other parameters. It was also found that horizontally aligned patches worked best, and a rotation of 45 degrees was better than 0 degrees or 90 degrees. This distinctive feature introduces a blend of radial and circumferential texture allowing variations in either or both directions to contribute to the iris code.

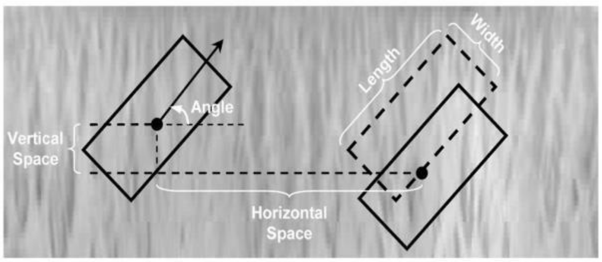


Fig.9 Overlapping angular patches with their various parameters.

To form image patches, we select bands of pixels along 45 degree lines through the image. A practical way of doing this is to slew each successive row of the image by one pixel compared to its predecessor. Patches are then selected in 11 overlapping horizontal bands as in Fig. 10. Each patch has eight pixels vertically (overlapping by four) and 12 horizontally (overlapping six). In the horizontal direction, a weighted average under a 1/4 Hanning window is formed. In effect, the resolution in the horizontal (iris circumferential) direction is reduced by this step. Averaging across the width of the patch helps to reduce the degrading effects of noise and the use of broad patches makes for easier iris registration.

In the vertical direction (45 degrees from the iris radial), eight pixels from each patch form a 1D patch vector, which is then windowed using a similar Hanning window prior to application of the DCT in order to reduce spectral leakage during the transform. The differences between the DCT coefficients of adjacent patch vectors are then calculated and a binary code is generated from their zero crossings. These 8-bit code fragments (codelets) are the basis of our matching process.

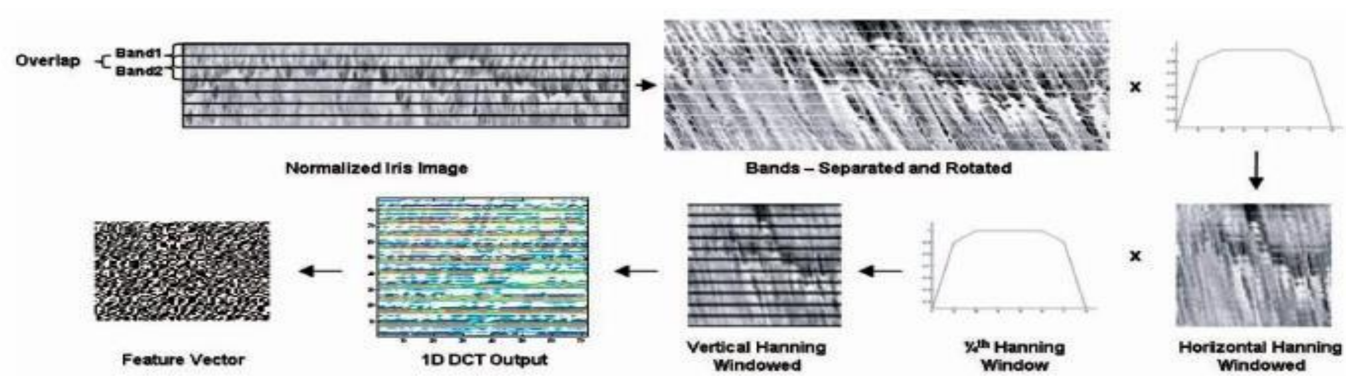


Fig.10 illustrating the various steps in forming feature vectors from normalized iris images.

IV. MATCHING

For comparing two iris codes, a nearest-neighbor approach is taken, where the distance between two feature vectors is measured using the product-of-sum (POS) of individual subfeature Hamming distances (HD). This can be defined as follows:

$$HD = \left(\prod_{i=1}^{M} \frac{\sum_{j=1}^{N} (SubFeature\,1_{ij} \ominus SubFeature\,2_{ij})}{N} \right)^{1/M}$$

Consider the iris code as a rectangular block of size MxN, M being the number of bits per subfeature and N the total number of sub features in a feature vector. Corresponding subfeature bits are XORed and the resultant N-length vector is summed and normalized by dividing by N. This is done for all M subfeature bits and the geometric mean of these M sums give the normalized HD lying in the range of 0 to 1. For a perfect match, where every bit from Feature 1 matches with every corresponding bit of Feature 2, all M sums are 0 and so is the HD, while, for a total opposite, where every bit from the first Feature is reversed in the second, MN/N sare obtained with a final HD of 1. Since a total bit reversal is highly unlikely, it is expected that a random pattern difference should produce an HD of around 0.5.

V. CONCLUSION

In the eyelash removal method , by detecting the direction of an occluding eyelash, we are able to replace affected pixels by intensity values that reproduce local image texture well enough to allow the region to be included in the coding of an iris.

One dimensional Discrete Cosine Transform Approach (1D-DCT) approach to human iris recognition supersedes earlier work in this field. This method has better performance, better accuracy. High speed performance at feature extraction level reduces total time for entire process. Simple method of Hamming distance calculation can be applied for matching of two iris code.

VI. FUTURE SCOPE

Discrete wavelet transform has become a widely used feature extraction tool in pattern recognition and pattern classification applications.. The technique uses all the frequency resolution planes of Discrete Wavelet Transform (DWT). These frequency planes provide abundant texture information present in an iris at different resolutions. It will improve the accuracy.

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