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A Novel Multi-Resolution Approach Based on Discrete Sub-Band Transform (DST) for Iris Texture Analysis and Recognition

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Abstract-- The randomness of iris pattern makes it one of the most reliable biometric traits. In this paper, after a thorough analysis and summarization, we propose a novel multi-resolution approach based on Discrete Sub-band Transform (DST) for iris texture analysis and recognition for extracting the unique features from the acquired iris image. This has resulted in a compact and efficient feature vector. In addition, a fast matching scheme based on hamming distance is proposed where the result experimentation was carry out using CASIA (v4) database. The experimental results have shown that the proposed system yields attractive performances and could be used for personal identification in an efficient and effective manner and comparable to the best iris recognition algorithm found in the current literature.

Keywords—Biometric, Iris segmentation, Iris normalization, CASIA (version 4)

I. INTRODUCTION:

In the present world with the advancing technologies, the necessity of security increases. So far we know the traditional security systems, such as the ID cards and passwords are still in existence. But yet they don't provide an individual's unique identification. For instance, the ID cards may be lost or the passwords may be forgotten. To overcome these unreliable security systems, the physiological and behavioral characteristics of individuals are used which paved the way for biometrics. The physiological characteristics (iris, retina, fingerprints, palm-prints, hand geometry) and behavioral characteristics (handwritten signature, voiceprint, gait, gesture, etc) are used as biometric traits. A good biometric is characterized by use of a feature that is highly unique – so that the chance of any two people having the same characteristic will be minimal, stable – so that the feature does not change over time, can be easily captured – in order to provide convenience to the user and prevent misrepresentation of the feature. Biometrics which analyze the complex and unique characteristics of the eye can be divided into two different fields. (a) Iris biometrics - iris is the colored band of tissue that surrounds the pupil of the eye. (b) Retina biometrics - retina is the layer of blood vessels at the back of the eye. Iris, that is, annular part between the pupil and the white sclera provides many interlacing minute characteristics such as freckles, coronas, stripes, furrows, crypts and so on. It is essentially stable over person's life, most reliable and accurate biometric identification.Visual texture of the iris stabilizes during the first two years of life and carries distinctive information useful for identification

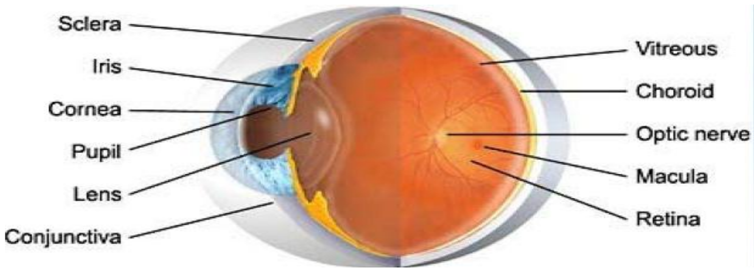


fig.1 Anatomy of the eye.

II. BASICS OF IRIS RECOGNITION SYSTEM:

The basic steps involved in iris recognition are as follows:

A. Image Acquisition- The most important step in iris recognition is to obtain a good and clear eye image. It helps in noise removal and avoids errors in calculation.

B. Segmentation (or Localization)-The inner and the outer boundaries ofthe iris are calculated.

C. Normalization- Iris of different people may be captured in different size, for the same person also size may vary because of the variation in illumination and other factors.

D. Feature Extraction- Iris provides abundant texture information. A feature vector is formed which consists of the ordered sequence of features extracted from the various representation of the iris images.

E. Matching- The feature vectors are classified through different thresholding techniques like Hamming Distance, weight vector and winner selection, dissimilarity function, etc.

III. EXISTING WORK:

In 1936, an ophthalmologist Frank Bruch propose a concept of using iris patterns as a method of recognize an individual In the year 1885, a French ophthalmologist, Alphonse Bertillon 1rst proposed iris pattern as a basis for personal identification In 1987, Flom and Safir obtained an unimplemented concept of automated iris biometrics system. A report was published by Johnston in 1992 without any experimental results. Dr. Flom approached Dr. John Daugman to develop algorithm for automated identification of human Iris. 1993, Defence Nuclear Agency began to work to tiniestand deliver prototype unit, which was successfully completed by1995 due to combine effort of DrsFlom, Sa_r and Daugman. In 1994 Dr. Daugman awarded for patent for his automated iris recognition algorithm. The first known algorithm for iris recognition is due to Daugman[1] based on phase texture analysis. The algorithm is based on Iris Codes generated using 2D Gabor wavelet. The accuracy obtained in the iris recognition system is found to be more. Another major contribution is due to Wildes[3]. The algorithm has made use of an isotropic band-pass decomposition derived from application of Laplacian of Gaussian Filters to the image data. This algorithm explicitly models the upper and lower eyelids with parabolic arcs whereas Daugman[1] excludes the upper and the lower portions of the image. The results of this system are good enough to recognize the individuals in minimum time period. Boashash and Boles[5] have presented a new algorithm based on zero-crossings. In this algorithm the zero-crossings of the wavelet transform are calculated at various resolution levels over concentric circles on the iris. Resulting one-dimensional (1-D) signals are then compared with the model features using different dissimilarity function. A similar type of system has been presented which is based on zero-crossing discrete dyadic wavelet transform representation and has shown a high level of accuracy. Multi-resolution Independent Component Identification (M-ICA) which provides good properties to represent signals with time frequency is used in to extract the features of iris signals. The accuracy obtained is found to be low because the M-ICA does not give good performance on class-separability. Dargham et. al. has used self- organizing map networks for recognizing the iris patterns. The accuracy obtained by the network is around 83. Chen [7] and Yuan have developed the algorithm for extracting the iris features based on fractal dimension. The iris zone is partitioned into small blocks in which the local fractal dimension features are computed as the iris code and finally the patterns are matched using the k-means and neural networks. Gabor filters and 2-D wavelet transforms are used by Wang [9] et. al for feature extraction. For identification weighted Euclidean distance classification has been used. This algorithm is invariant to translation and rotation and tolerant to illumination. The classification rate on using Gabor is 98.3 and the accuracy with wavelets is 82.51. Robert has presented a new algorithm for localization and extraction of iris. For localization a combination of the integro-differential operators with Hough transform is used while the concept of instantaneous phase or emergent frequency is used for feature extraction. Iris code is generated by thresholding both the models of emergent frequency and the real and imaginary parts of the instantaneous phase. Hamming distance is used for matching. The recognition ability of classifiers depends on the quality of feature used as well as the amount of training data available to them. Image features are mostly extracted on shape and texture of segmented objects. Iris Recognition Based on Combined Feature of GLCM and Wavelet Transform 2010 First International Conference on Integrated Intelligent Computing this paper present a method for iris recognition based on hybrid feature set of wavelet and GLCM features, a non-filter based technique, combined with Haar wavelet transform to increase the efficiency of the system [8]. Here we combine frequency domain feature with spatial domain feature to increase overall efficiency of system. Probability neural Network is used to classify the features. Results show that the overall system efficiency is 94 with false rejection rate higher than false acceptance rate.

IV. PROPOSED WORK:

The proposed method is a novel multi-resolution approach based on Discrete Sub-band Transform for iris texture analysis and recognition.The development of this approach is motivated by the observation that dominant frequencies of iris texture are located in the low and middle frequency channels.

A. IRIS IMAGE ACQUISITION:- To test the proposed work, data set of Chinese Academy of Sciences- Institute of Automation (CASIA) version-4 is used. The captured iris images are 8-bit gray level images with a resolution of 320 x 280. The CASIA database includes 22051 iris image sequences from 700 subjects. This is largest image database available in public domain.

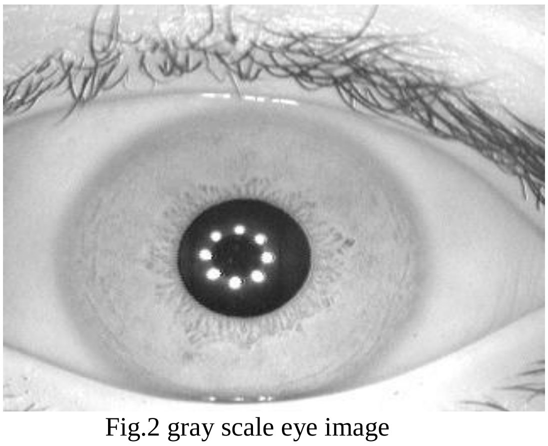
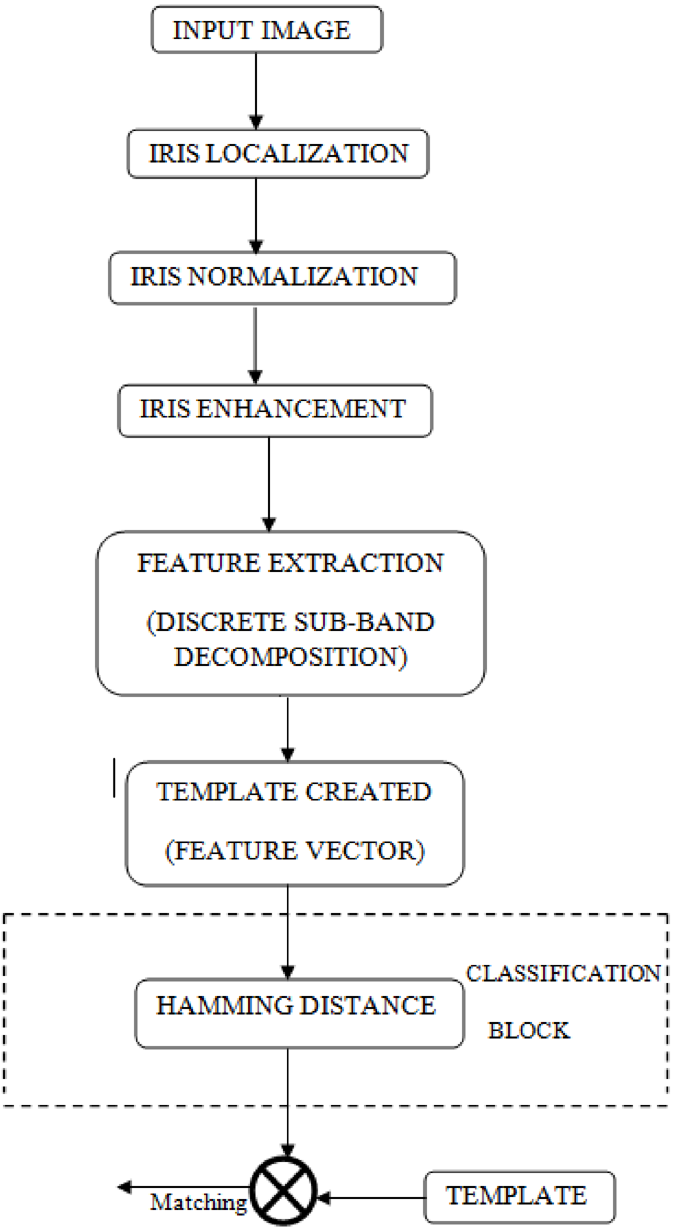


Fig.2 gray scale eye image

STAGES OF IRIS RECOGNITION



B. IRIS LOCALIZATION (OR SEGMENTATION):- The first stage in iris recognition is the detection of pupil and Iris boundaries from the input eye images. Circular Hough transform is used to detect pupil and iris boundaries. This involves first employing canny edge detection to generate an edge boundary. Also eyelids, eyelashes and reflection areas if any, need to isolate. Eyelids can be isolated by using linear Hough transform. Threshold can be employed for isolating eyelashes and reflections.

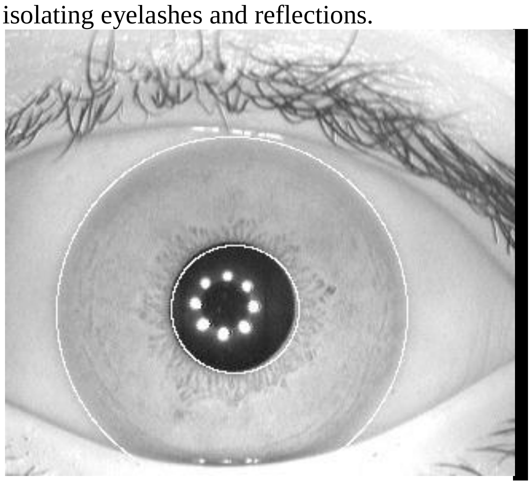


Fig.3 segmented image

C. IRIS NORMALIZATION:-Irises from different people may be captured in different size and even for irises from the same eye; size may change due to illumination variations and other factors. Such elastic deformation in iris texture will affect the result of Iris matching. Image processing of the eye image is computationally expensive as the area of interest is of donut shape grabbing the pixels in this region require repeated rectangular to polar conversion. This problem can be solved by projecting the original iris in a Cartesian co-ordinate system into doubly dimensionless pseudo polar co-ordinate system. This method normalizes iris of different sizes to the same size. The remapping of the iris region from (x,y) Cartesian coordinates to the normalized Non-concentric polar representation is modeled as

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

With

$x(r, \theta) = (1- r)\, xp(\theta) + r\, xi(\theta)$

$y(r, \theta) = (1- r)\, yp(\theta) + r\, yi(\theta)$, where-

I(x,y)= iris image
(x,y) = original cartesian coordinates
(r, θ) = normalised coordinates
(xp, yp)= pupil coordinates
(xi, yi)= iris coordinates along θ direction.

Fig.4 polar array after normalization

D. FEATURE EXTRACTION:- Wavelet transform approach used is Discrete Sub-band Transform for feature extraction phase. Wavelet transform provides flexible time frequency resolution properties; one possible drawback is that frequency resolution is rather poor in the high frequency region. Optimal Sub-band(or Wavelet packets), a generalization of a wavelet bases, are alternative bases that are formed by taking linear combination of usual wavelet functions.The advantage of optimal sub-band analysis is that it is possible to combine the different levels of decomposition in order to achieve the optimum time-frequency representation of the original. Thus discrete sub-band transform of decomposition level 5 is used for the purpose of feature extraction. Wavelet family (mother wavelet) used is Daubechies wavelet. Discrete sub-band decomposition is applied to iris images using Daubechies wavelet packets filters.

E. TEMPLATE MATCHING:- The Hamming distance was chosen as a matching metric,

$$HD = \frac{\text{No. of bits different}}{\text{Total no. of bits}}$$

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 bits in the bit pattern. 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. 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.

V. EXPERIMENTAL RESULTS:

Data Analysis: The proposed algorithm is tested on CASIA iris image database CASIA-IrisV4[11] developed by the Chinese Academy of sciences-Institute of Automation. The CASIA database includes 22051 iris image sequences from 700 subjects. This is largest image database available in public domain. The captured iris images are 8-bit gray level images with a resolution of 320 x 280. In general the diameter of the iris in images from this database is greater than 200 pixels. This makes sure that there is enough texture information for reliable recognition. The CASIA database consists of clear images, motion blurred images, occluded images and defocused images in different numbers. The proposed iris recognition algorithm is tested in two modes-

- Identification (i.e. one-to-many matching)
- Verification (i.e. one-to-one matching)

In identification mode, algorithm is measured by correct Recognition Rate (CRR), the ratio of the number of the samples being correctly classified to the total number of the test samples.

In verification mode, FRR (False Rejection Rate) and FAR (False Acceptance Rate) will be used for measure of accuracy process and shows the overall performance of an algorithm. FRR measures the probability of an enrolled individual not being identified by the system. FAR measure the probability of an enrolled individual being wrongly identified as another individual. The false accept and false reject rates can be calculated by the amount of overlap between two distributions.

The accuracy of recognition with this distribution can be determined by calculating their false accept rates (FAR) and false reject rates (FRR) with different threshold

FAR = 0ΣkHD/ 0Σmax HD ;

FRR = kΣmax HD / 0Σmax HD

Where,

k is the separation point (threshold) between intra-class and inter-class.

Table1.FAR and FRR for different threshold

Threshold	FAR (%)	FRR (%)
0.20	0	7
0.40	0	4
0.60	0	4
0.80	0	3
1.0	0	3
1.2	2	3
1.4	5	2
1.6	5	0
1.8	8	0
2.0	10	0

Table2. Comparison With existing methods (CRR)

Method	CRR (%)	ERR(%)
Daugman	100	0.08
Boles	92.64	8.13
Existing	93	6
Proposed	99.98	0.012

Table3. Comparison With existing methods (Time)

Method	Feature Extraction time	Matching time
Daugman	200msec	430 u sec
Existing	54msec	47 u sec
Proposed	21.7msec	31.4 u sec

GRAPHS:

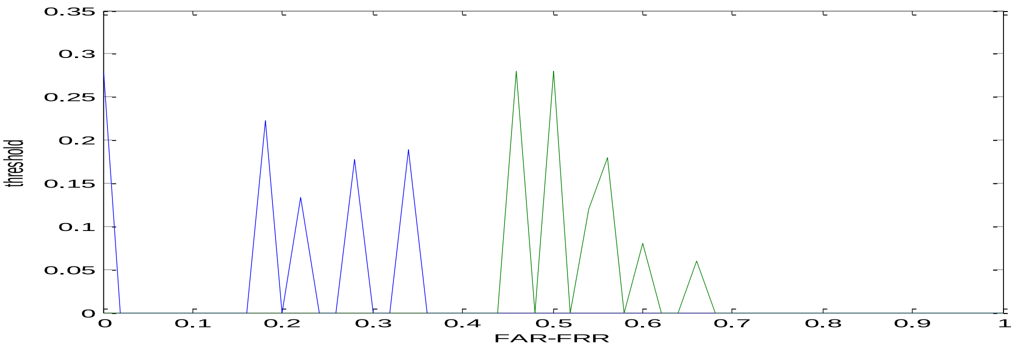


Fig.5 FAR-FRR for different threshold (no overlapping with threshold value =0.4)

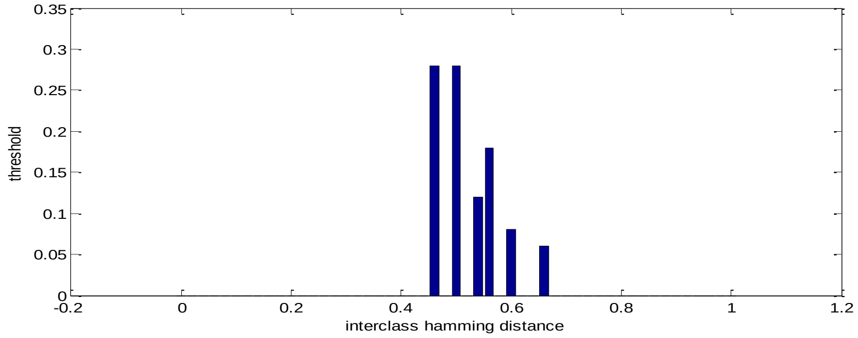


Fig.6 inter-class hamming distance distribution

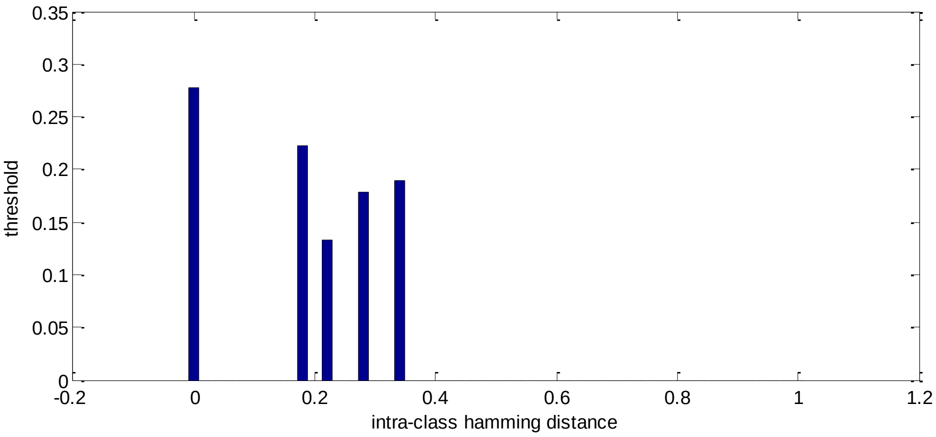


Fig.7 intra-class hamming distance distribution

VI. CONCLUSION:

The proposed method is a novel multi-resolution approach based on Discrete Sub-band Transform for iris texture analysis and recognition. Wavelet family (mother wavelet) used is Daubechies wavelet with decomposition level of 5. Computational complexity of Daubechies wavelet is less as compared to Gabor wavelets. Daubechies, called compactly supported orthonormal wavelets, make discrete wavelet analysis practicable. Discrete sub-band decomposition is applied to iris images using Daubechies wavelet packets filters with energy. An energy measure is used to identify the particular packet that carries discriminating information about the iris texture. The experimental results show 99.98% correct classifications when applying the algorithm on an iris image database.

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