An Approach of Combining Iris and Fingerprint Biometric At Image Level in Multimodal Biometrics System

S. M. Rajbhoj, P. B. Mane

Abstract*—Biometric systems depending on single source of information has many limitations. These are noisy input data, inability to enroll, unacceptable error rates, universality of traits and spoofing. Multimodal biometric system overcomes these limitations by combining information from multiple sensors. In Image fusion usually images are extracted from single trait using different sensors. This type of fusion is generally used when feature set are homogenous. In this paper a multibiometric system using image level fusion of two most used biometric traits, fingerprint and iris is proposed. The feature set obtained from iris and fingerprint images are incompatible, non-homogenous and relationship between them is not known. Here the pixel information is fused at image or feature level. A unique feature vector is constructed from the textural information of fused image of fingerprint and iris. Feature vector is stored as template and used for matching. Matching is carried using Hamming distance. The proposed framework is evaluated using standard database and database created by us. The system overcomes limitation of unimodal biometric system and equal error rate of 0.4573 has been achieved.

***Index Terms*—biometric, fingerprint, iris; wavelet transform, texture, feature level, fusion, hamming distance.**

I. INTRODUCTION

Biometric system is human identification or verification system based on physiological and/or behavioral characteristics (traits) of an individual. With this system it is possible to authorize or establish an individual's identity based on "who he is", rather than by "what he has" or "what he remembers". Some of the trait associated with an individuals are fingerprint, face, iris, hand geometry, signature, voice, palm print, etc. [1]. Unimodal biometric system performs person recognition based on single source of biometric information. These systems have to contend with of number of limitations such as intra-class variations, inter-class similarities, spoof attacks and universality of trait. Apart from these, noisy data resulting from defective sensors, the high failure rates (failure to enroll rate and failure to capture rate) and scalability are other problems associated with these systems. Multimodal biometric system seeks to overcome some of these limitations by merging the characteristics presented by multiple biometric information sources. It combines information from two or more biometric modalities in a single system. It may fuse information from multiple biometric traits, multiple sensors, multiple representations, multiple snapshots or matching algorithms [2] [3].

In this paper we present a novel approach of combining iris and fingerprint biometric at feature level in a multimodal biometric system. Next section gives review of past work; a brief framework of proposed multimodal system is presented in section 3. In Section 4 experimental results are presented. Section 5 concludes the paper.

II. REVIEW OF PAST WORK

A variety of information fusion methods are proposed in literature. They are broadly classified depending on levels at which the information is fused: decision level, rank level, score level, feature level and sensor or image level.

The decision of individual matchers is combined together at decision level in decision level fusion. Prabhakar, S. and Jain, A. K [4] presented a scheme for combining three minutiae-based algorithms (Hough, string and dynamic based) and one texture-based algorithm classifier (matched filter) at decision level for fingerprint verification.

In multimodal biometric system, rank level fusion has been rarely used to combine the biometrics matching scores. Bhatnagar, J., Kumar, A., Saggar, N., used Borda count method to combine the output of different matchers to form a combined rank [5].

Several traits were fused at score level to improve performance accuracy in multimodal biometrics.

L. Hong and A. K. Jain [6] fused face and fingerprint traits of an individual for person identification at match score level. Normalization technique was used to improve accuracy.

A hand based verification system that combines the geometric features of the hand with palm prints at the feature and match score levels is described by Kumar et al. [7]. Their results showed that match score level fusion outperforms feature level fusion.

Fierrez-Aguilar et al [8] fused global and local features of the signature using max and sum rule.

Face and iris traits of an individual were combined by Y. Wang, T. Tan, and A. K. Jain [9] using two strategies. The first computes un-weighted, weighted sum and second one uses Fisher's discriminant analysis and neural network with radial basis function (RBFNN).

Match score level fusion combines scores generated by various classifiers were also proposed. A. Ross, A. K. Jain, and J. Reisman [10] used both minutiae and ridge flow information to represent and match fingerprints in hybrid fingerprint recognition system.

Three different types of feature sets from the face image of a subject using three classifiers, namely Principal

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Component Analysis (PCA), Linear Discriminant Analysis (LDA) and Independent Component Analysis (ICA) were integrated at the match score level using two strategies sum rule and radial basis function (RBF) network by X. Lu, Y. Wang, and A. K. Jain [11].

Feature level or sensor level fusion integrates either the feature set originating from different sensors or sensor data itself.

G. L. Marcialis and F. Roli merged the fingerprint information of a user obtained using an optical and a capacitive fingerprint sensor [12].

K. I. Chang, K. W. Bowyer, and P. J. Flynn [13] used both 2D and 3D images of the face and fused them at the data level to improve the performance of a face recognition system.

Ross and Govindarajan [14], describes an intra-modal fusion involving the R, G and B color channels of the face images by using Linear Discriminant Analysis (LDA) on each color channel independently. Three feature sets were then fused at both the feature and match score levels.

Both iris and fingerprint are highly accurate biometric identifiers. But under certain condition the user is not able to give his proper iris image due to ambient light, handling of devices, problematic iris scanners, eye diseases or absence of that trait. Fingerprint recognition system can also create problem if scars and cuts are present on fingertip or sensor is unable to capture fingerprint images of certain individual due to various reasons. Although there has been much research on combining different biometrics for a variety of purposes, biometric fusion techniques have been developed only for fingerprint and face, face and gait, audio and face. So far there is less consideration on the combining finger print and iris, which are two characteristics that can reach the best recognition performance for high safety applications [15][16]. Here an attempt is made to combine these two identifiers at feature or image level.

III. THE PROPOSED MULTIBIOMETRIC SYSTEM

The proposed system mainly consists of fingerprint feature extraction module, iris feature extraction module, fusion module and matching module. Fingerprint feature extraction module consists of fingerprint acquisition, enhancement and resizing of fingerprint image and discrete wavelet transformation (DWT). In iris module first the iris region is segmented from eye image and then it is normalized before applying DWT. Haar wavelet transform is been used. This breaks the fingerprint and iris image into four subsamples XX, XY, YX, YY, where X and Y means high pass and low pass filter. XX of both fingerprint and iris are fused together and a unique feature vector is extracted from this fused image. Classification of feature vector is carried out using Hamming distance. The block diagram of proposed system is as shown in Fig. 1.

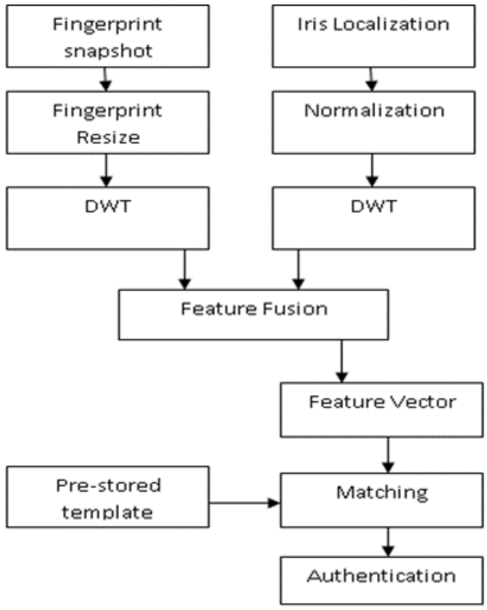


Fig.1. Block Diagram of the proposed system.

A. *Fingerprint Feature Extraction Module*

Fingerprint image is captured with optical sensor U are U 4500 fingerprint reader designed by Digital Persona which is capable of capturing sufficient discriminative information. The subject places the finger on the glowing reader window and image is automatically scanned. The scanned data is send over the USB interface. This reader utilizes optical fingerprint scanning technology to capture a large area [14.6 x 18.1] image with excellent image quality [512 DPI]. The fingerprint image is then pre-processed. This step mainly consists of image enhancement and resizing the image for further operations. DWT is then carried out on enhanced fingerprint image. Wavelets are used to decompose the image data into components that appear at different resolutions. Wavelets have the advantage over traditional Fourier transform in that the frequency data is localized. A number of wavelet filters, also called a bank of wavelets, is applied to the image, one for each resolution with each wavelet a scaled version of some basis function. The output of applying the wavelets is then encoded in order to provide a compact and discriminating representation of the finger pattern. The Haar wavelet is one of the simplest wavelet transforms which can transform huge data sets to considerably smaller representations [19]. Here we use Haar wavelet transform. De-composing images with wavelet transform yields a multi-resolution from detailed image to approximation images in each level. The sub-images (quadrants) within the image indicated as XY, YX, and YY represent detailed images for horizontal, vertical, and diagonal orientation, respectively in the first level. The sub-image XX corresponds to an approximation image that is further used as an input to fusion module.

B. *Iris Feature Extraction Module Fingerprint*

The iris is acquired as a part of an image that contains information derived from the eye region. The main stages iris feature extraction module are iris localization, normalization and discrete wavelet transform. Localization consists of, determining the boundary of iris and pupil and removal of eyelids and eyelashes. To detect the iris and pupil contour integro-differential operator [18] is used. The integro-differential operator is defined as

$$max(r, xp, y0) \left| GS\sigma(r) * \frac{\partial}{\partial r} \oint_{r,x0,y0} \frac{A(x,y)}{2\pi r} ds \right| \quad (1)$$

Where *A (x, y)* is the eye image, *r* is the radius of the search, *G Sσ (r)* is a Gaussian smoothing function and *s* is the contour of the circle given by *r, x, y*. The integro-differential operator searches for the circular path having maximum change in pixel values, by changing the radius and center x and y positions of the circular contour. The operator is applied in repetition with the amount of smoothing gradually reduced in order to attain accurate localization. The output gives the center co-ordinates and radius of iris and pupil. Next the eyelids and eyelashes if present are removed by linear Hough transform.

Once the iris region is successfully segmented from an eye image, the next stage is to transform the iris region into fixed dimensions. This process called normalization produces iris regions, which have the same constant dimensions. Daugman's rubber sheet model [18] is used for it. The center of the pupil was considered as the reference point, and radial vector pass through the iris region. A number of points are selected along each radial line and this is defined as the radial resolution(*r*) and it is in vertical dimension. The number of radial lines going around the iris region is defined as the angular resolution (*Ɵ*) and it is in horizontal dimension. If the pupil is non-concentric to the iris, a remapping formula [19] is used to rescale points depending on the angle around the circle. This is given by "2".

$$r' = \sqrt{(\alpha\beta)} \;\pm\; \sqrt{(\alpha\beta^2 - \alpha - a^2)} \quad (2)$$

Where

$$\alpha = X^2 + Y^2,$$

$$\beta = \cos(\pi - \arctan\left(\frac{Y}{X}\right) - \theta)$$

Where displacement of the center of the pupil relative to the center of the iris is given by *X*, *Y* and *r*' is the distance between the edge of the pupil and the edge of the iris at angle *Ɵ* around the region, and "*a*" is the radius of the iris.

Next discrete wavelet transform is applied to normalized iris image. Haar wavelet is used to generate four bands of coefficients [20]. This breaks the iris image into four subsamples XX, XY, YX, YY, where X and Y means high pass and low pass filter. XX sub image is used for further processing.

C. Fusion Module

In multimodal biometric system employing image fusion usually images are extracted from single trait using different sensors. The features extracted from these images are not independent, and hence it is reasonable to concatenate the two feature vectors into single new vector. The new vector has high dimensionality and represents identity in different space. Further feature reduction techniques are used to reduce the size of feature vector. This type of Feature fusion is generally used when feature set are homogenous. Here a new distinct method of fusion is been proposed in which fingerprint and iris images are fused as feature set obtained from iris and fingerprint images are incompatible, non-homogenous and relationship between them is not known . The outputs of feature extraction modules are sub images (XX band) of original fingerprint and iris images. The DWT coefficient of each fingerprint XX subsample and iris XX subsample are fused together. From this fused image one dimensional vector is extracted which is treated as a single template vector.

D. Matching Module

When a live fingerprint and iris is presented for comparison, the fingerprint and iris pattern is processed, textural information of fingerprint and iris are extracted and encoded into single template vector. The feature template vector derived from this process is compared with previously stored feature vector. This process is called matching. Matching evaluates the goodness of match between the newly acquired vector and the candidate's data base entry. Based on this goodness of match, final decision is taken whether acquired data does or doesn't come from the same fingerprint and iris as does the database entry. Hamming distance is the distance measure used which is given as

$$HD = 1/B \sum_{i=1}^{B} Xi \; [EXOR] \; Yi \quad (3)$$

Where, *Xi* and *Yi* are query and database codes and B number of bits.

IV. EXPERIMENTAL RESULTS

The fingerprint database was prepared by obtaining fingerprint images from U are U 4500 Fingerprint reader designed by Digital Persona [21]. We acquired eight fingerprint images per subject for a total of twenty subjects to have a database of 160 images. For iris database we have used the CASIA v4 database [22] which was obtained from

Institute of Automation, Chinese Academy of Sciences. We have selected iris images of twenty subjects and taken eight images of each subject. As both these databases are independent hence each fingerprint was assigned a corresponding iris image. The database thus formed had fingerprint and iris data from 20 users each having eight fingerprint images and eight iris images. The proposed algorithm is implemented in MATLAB. The graphic user interface (GUI) of proposed system is as shown in Fig 2.

The algorithm is tested on fingerprint and iris databases by matching feature vector of query images and database feature vector. Hamming distances were the measure used for matching these feature vectors. The Hamming distance, if less than threshold indicates, that the feature vector belongs to the same person otherwise it is of different persons.

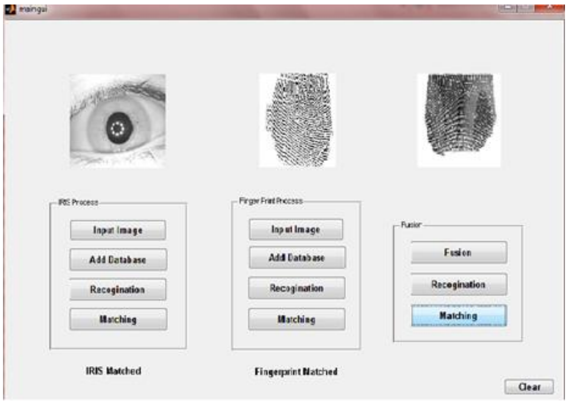


Fig.2. Graphic User Interface of proposed system.

Each feature vector is matched with every feature vector of the database. This results in 1280 mate subject and 24320 non mate subjects. The scores of the mate subjects are genuine scores and scores of non-mate subjects are imposter scores. Thus we get 1280 genuine scores and 24320 imposter scores. Different threshold indicates to different values of false accept rate (FAR) and false reject rate (FRR). The FAR v/s threshold plot and FRR v/s threshold plot is as shown in Fig 3.

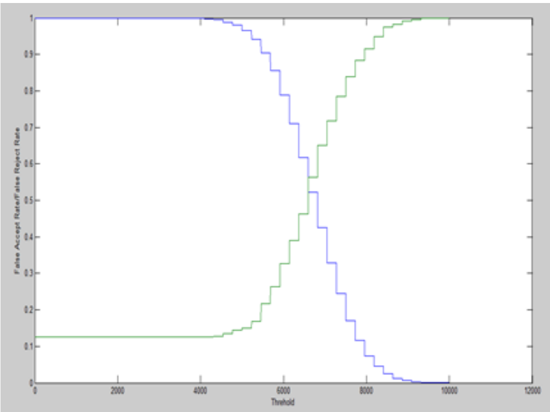
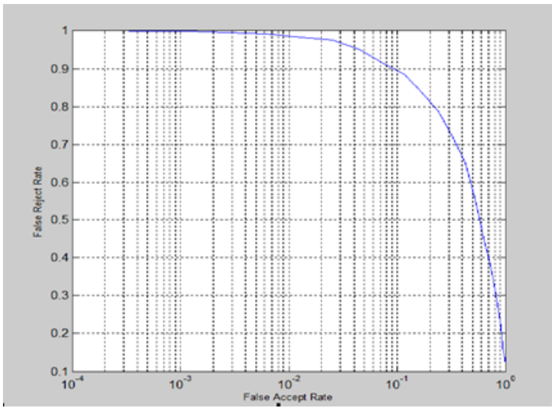


Fig.3. False Accept Rate, False Reject Rate v/s threshold plot.

The overall performance of this algorithm is brought together in by plotting receiver operating characteristics (ROC). ROC plot is a plot of false accept rate (FAR) and genuine accept rate (GAR) for all apparent thresholds, each point on the curve corresponds to particular threshold. The ROC plots are given below. Fig. 4 shows plot of FAR and FRR.



The Fig.4. Receiver Operating Characteristics plot (FRR v/s FAR).

From the figure for the False accept rate of 0.01 we get False reject rate of 0.98. With the proposed multimodal system we have achieved an equal error rate (EER) of 0.4573 compared to EER achieved by A. Baig et al. 2.86 [21] and Conte et al. 2.36 [22]. A plot of false accept rate (FAR) and genuine accept rate (GAR) is shown in Fig. 5.

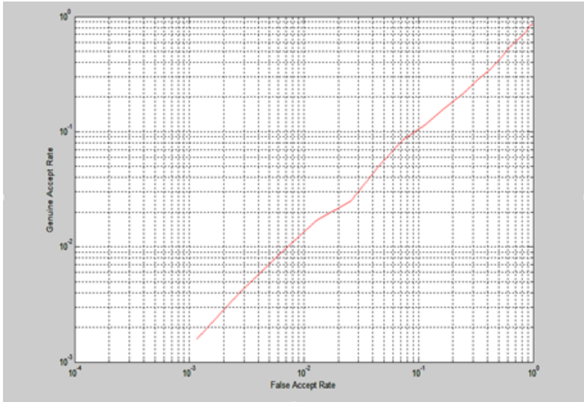


Fig.5. Receiver Operating Characteristics plot (GAR v/s FAR).

V. CONCLUSION

In recent years the interest in fusion in multiple biometrics has increased due to increasing importance of security, limitation of biometric systems and more number of spoof attacks. In this paper, a novel multimodal biometric system using fingerprint and iris is presented where the information is fused at feature level. The proposed framework is presented as an alternative option of using multiple security systems in high security applications addressing the issues of non-universality, spoof attacks and limitation of unimodal systems. The result also confirms that it is possible to fuse fingerprint and iris at feature level, even though their features at image level are incompatible and non-homogeneous. This system provides single feature vector obtained by fusing fingerprint and iris image and extracting a unique textural pattern from fused image by efficient wavelet transform. The reduced size of feature vector speeds the matching process. This system also provides resilience to processing attacks.

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