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Biometric Recognition System Based On Mergence of Three Human Traits

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Abstract— This paper designs a Hybrid Biometric System which integrates together three human modalities: fingerprint, iris and face to outperform single modality based system. Light is thrown on all the algorithms used for pre-processing, normalisation and feature extraction. Skeletonization process for fingerprint processing and Hough transform for iris processing are explained clearly. DWT shows how images are split up into four fragments of feature values. Various performance parameters are calculated to prove the superiority of this system
Keywords— Skeletonization, Hough Transform, 2-D DWT, Normalisation, Zero-padding, Performance parameters.

I. INTRODUCTION

Several systems regulate access to financial transactions; computer based networks or protected office buildings by recognition of passwords or PINS (personal identification numbers). The drawback of such systems is that illegitimate people can steal others' passwords and numbers very easily and then make use of them without early perception. Biometric recognition systems fortify more protection than these password and number based verification systems as it employs physical & behavioral features to keep a check on person's individuality. Human traits like face orientations or fingerprint samples can be saved on a chipset, for example in a debit card. If the card is stolen by an imposter and put to use then there would be strong mismatch between the saved modalities and the features of the robber. This would prevent any further transaction/mishappening to occur. However, a single feature many a time fails to be sufficient for recognition. For example, take up the case of identical twins. Their faces alone are not enough to provide a sharp segregation. Also a chosen single feature is not always decipherable. For example, record of fingerprints for certain individuals (hand injured patients) cannot be maintained due to obscurity caused with a deep scar or a cut. Thus there emerges out the multimodal biometric systems.

A multimodal recognition system uses multiple different features to spot the individuals. They achieve greater precision than single feature based biometric systems. By any means even if one of the modalities is disrupted, for example if the user blinks the eye at the time of image capture such that the iris part is only partially recorded or a very bright light is shown in the background of captured eye image such that it prohibits the system to segment out the required iris section, then the rest of the two modalities (fingerprint and face) still escort the system to deliver explicit recognition. These advantages make multimodal biometric systems more secure against spoof attacks in comparison to systems plying only the static human features. Putting light on the work of previous researchers, we see a lot of contribution done by them in this field. Hong et al. [1] have designed a fusion system by concatenation of face and fingerprints where face templates are matched before shearing the database with matching of fingerprints. Ross et al. [2] used combination of fingerprint, hand geometry and face to design a biometrics. He implemented linear discriminant analysis, sum- rule and decision tree techniques. They proved experimentally that sum rule performs better than others. Brunelli et al. [3] make use of hyperbolic tangent (tanh) for the normalization process and weighted average method for integration of face and voice biometric systems. Yacoub et al [4] tried fusing face and voice traits and then validated the designed system's performance using various classifiers like SVMs (support vector machines), tree classifiers, Bayes classifiers & multilayer perceptron based models. Kittler et al. [5] tried fusing face and voice modalities to design hybrid biometrics.

II. METHODOLOGY

This paper presents a hybrid multimodal biometric system which fuses together fingerprint, iris and face modalities to outperform the single modality based systems. The whole paper is segmented into 3 main parts: 1st part is the introduction to the topic. 2nd part contains the techniques followed. 3rd part discusses the results obtained and concludes the objectives attained. The system's functionality can be specified through the block diagram as shown in Fig.1.

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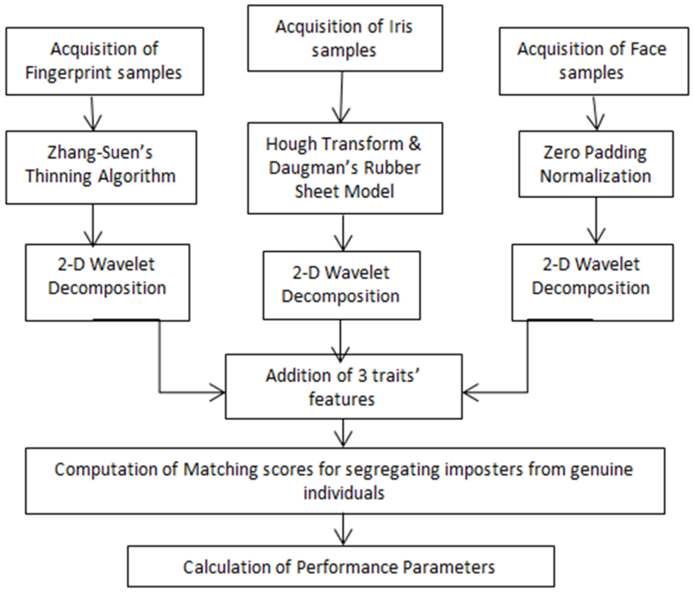


Fig.1 Block Diagram of the Multimodal Biometric System

Step by step the algorithm is explained in following sections.

A. Fingerprint

Thinning operation or skeletonization is performed by iterative erosion of redundant pixels from the considered image until only a skeleton or stick-like figure is left which narrates the image's object. This algorithm is implemented to compute a decreased data amount or to clarify the object's minute details for the purpose of feature extraction. It highlights the essential properties to be focused on by deleting the unwanted noise at the frontal part. The output of this thinning algorithm should justify two main criteria: Thinness at its maximum level yet descriptive and proper connectivity amongst the lines of the image. It is a sequential thinning method so the pixels are examined for deletion on basis of the results obtained from previous occurred iteration. The Zhang Suen thinning algorithm [6] is a fast iterative algorithm. It is based on the assumption that the region under consideration in the image has pixel value of '1' and the pixels in background have value of '0'. Two fundamental steps are applied in succession to all contour points of given area where a contour point is any pixel with value '1' & that has at least one 8-neighbor valued of '0'. In accordance with the definition of 8-neighborhood, the 1st step initiates a contour point "p" for deletion only if following conditions are fulfilled:

$$2 <= N(p1) <= 6.$$
$$Z(p1) = 1.$$
$$p2 * p4 * p6 = 0.$$
$$p4 * p6 * p8 = 0.$$

where N(p1) is number of nonzero neighbors of p1 i.e. N(P1)=P2+P3+........P8+P9 & Z(p1) is the number of 0 -1 transitions in the ordered sequence of p2, p3, ...p7, p8, p9. For instance, N(p1) = 4 & Z(p1) = 3 in Fig. 2.

P9	P2	P3	0	0	1
P8	P1	P4	1	P1	0
P7	P6	P5	1	0	1

Fig.2 Arrangement of 8-neighborhood pixel

In the 2nd step, above defined first two conditions remain the same but third and fourth conditions are changed to:

$$p2 * p4 * p8 = 0$$
$$p2 * p6 * p8 = 0$$

First step is applied to all border pixels of the area under processing. If one or more of the conditions the area violates, then the numerical count of point under consideration remains unchanged. If all the conditions are fulfilled by the area then the point is dropped out for deletion. It is interesting to be noticed that point isn't deleted until the processing of all the border points. This prohibits altering the data's structure during enactment of the algorithm. After first step has been implemented on all the points of the border, the ones which were flagged are removed i.e. changed to '0' for example. Then same way second step is applied to the remaining data.

(a) (b)

Fig.3 (a)Acquired fingerprint Sample (b) Thinned sample

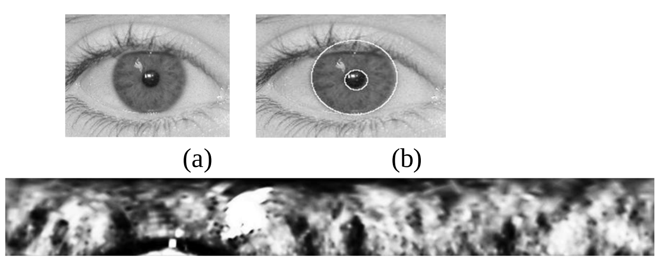
B. Iris

Canny's Edge Detector [7] along with Circular Hough Transform is applied for segmentation of iris from the image of eye [8]. The Canny's operator works in a multi-stage flow of smaller algorithms. Firstly all the acquired sample images are softened by using Gaussian convolution. It involves moving a Gaussian filter mask over the input image which is under processing. Then 2-D first derivative Prewitt operator is applied to blurred image to draw focus on those areas of image which have maximum first spatial derivatives. Gradient of image along with its orientation & magnitude is computed. Edges provide way for ridges in the gradient-magnitude image. The next algorithm then routes along the top of these edges and puts all the pixels that are not completely on the edge top to zero so as to produce a thin line as the resultant output. This process is called non-maximal suppression. The routing process delivers hysteresis that is controlled by two threshold values: *T1* and *T2* with *T1* > *T2*. Routing/following can only start at a point on an edge with value higher than *T1*. Tracking then keeps continuing in all the directions from that edge point until the value of the edge falls below *T2*. This hysteresis fortifies that edges due to noise don't crack up into smaller edge fragments.

Once the sharp edges are found out, then Circular Hough Transform [9] is used to find the boundary lining of all the edges. The algorithm works as follows. The parameter space is quantised for the parameters a and b. The accumulator matrix M(a,b) is set to zero. Then the magnitude of gradient G(x,y) and angle ā̄(x,y) is recalled from previous computations [10]. For every point of edge in G(x,y), all points of accumulator matrix M(a,b) are increased along the equation:

b = a tan ā̄- x tan ā̄+ y

where ā̄ is angle in range $[0, 2\pi]$. Normalization is then done using Daugman's Rubber Sheet Model [11] to convert the iris region segmented into fixed dimension image so as to make it compatible for comparison with other trait's images. It means two images of same iris under varying conditions will have specific features at same spatial location. It remaps all the points of the iris region to a pair of polar co-ordinates. This homogenous model accounts for non-concentric pupil displacement but it doesn't compensate for angular inconsistencies.



(a) (b)

(c)

Fig.4 (a) Acquired eye's image (b) Circled iris part (c) Normalized iris image

C. Face

In order to reduce processing time and computation time, not many enhancements have been done to face images. Only zero padding is done to normalize them.

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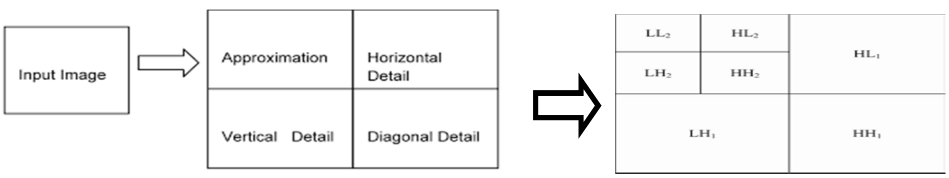
(a) (b)

Fig.5 (a) Acquired face's image (b) Normalized sample

D. Feature Extraction

The 2-D wavelet decomposition transform [12] imparts a suitable basis for image handling because of its advantageous attributes. It perfectly represents the low frequency components (such as background of image) and high frequency changes (such as edges of image). It provides decomposition with variable resolution yet uncorrelated coefficients. Each tile of input image at deliberate progress is sampled using a stack of low pass filters. The anatomy of the filtering process is as shown in figure 6 where H or L refer to highpass or lowpass filtering in vertical or horizontal direction. The subscript depicts the level of filtering. At every level, the low pass portion (LL) is recursively filtered using the same scheme.



(a) (b)

Fig.6 (a) 2-D Wavelet Split (b) More detailed view

Most of the needful data of the considered image is held up in the low frequency components while the high frequency components are more widely spread i.e. is sparser. This way features are extracted and saved in the form of templates.

E. Fusion

For every modality, a feature vector is obtained [13]. As the features extracted from one biometric modality are independent of those extracted from the other, it is rational to fuse all vectors into a single new vector. The new feature vector now has a higher dimensionality and represents a person's individuality in a more descriptive hyperspace. Fusion includes the merging of all the feature vectors before score calculation.

F. Score Calculation

The comparison of similarity between Ų1(feature vector from the 1st input sample) and Ų2 (feature vector from the 2nd input sample) is computed as follows:

$$\alpha = \frac{\sum \text{Ų}1 \ \text{Ų}2}{\sqrt{\sum \text{Ų}1 \ \ \sum \text{Ų}2}}$$

These matching scores differentiate the imposters from the genuine individuals. This equation calculates the normalized correlation between the feature vectors Ų1 and Ų2. During verification, if the matching score is less than some predefined threshold value then the sample is considered to be of an imposter otherwise it is taken up as of the genuine individual.

III. RESULTS & CONCLUSION

The experiments conducted in this paper pick up real time images of all the three traits. We have taken up 3x5x10 = 150 images in total where 3= number of traits, 5= number of images per trait's sample, 10= number of samples per trait. All these have been arranged in separate folders. The first five images from each user were used for training and the rest were used for testing. The code is implemented in Matlab. Figure 7 shows binomial distribution of imposters' and genuine individuals' matching scores.

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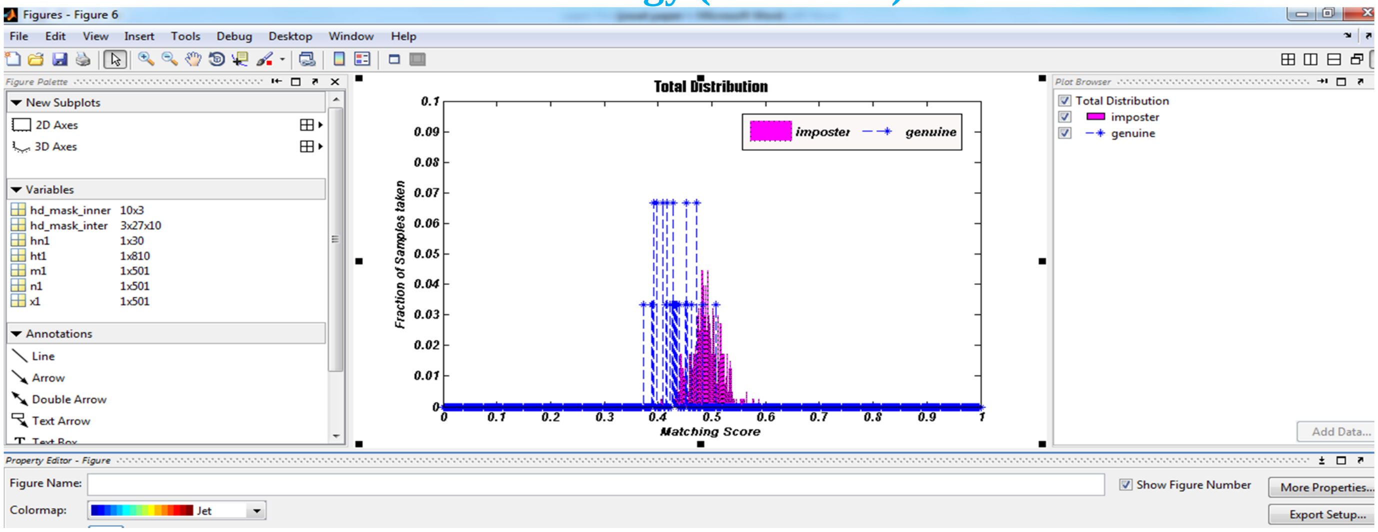

Fig.7 Distribution of Matching Scores between Imposters & Genuine Individuals as in Matlab

Various parameters are also calculated to show the good performance of the designed system.

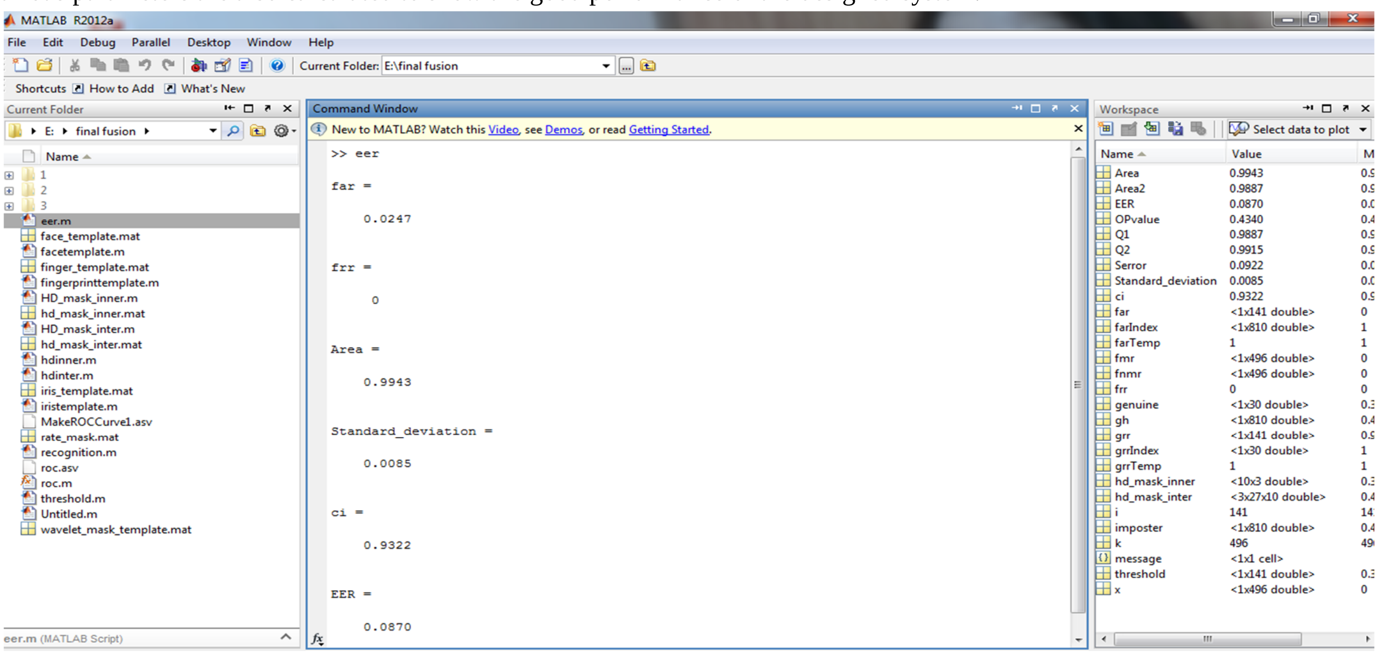

Fig.8 Results of various performance parameters

Thus we can conclude that biometric system based on emergence of three biometric traits: fingerprint, iris & face outperforms single modality based system [14]. False Acceptance Rate of 0.0247 is good enough to prove a system as an accurate system.

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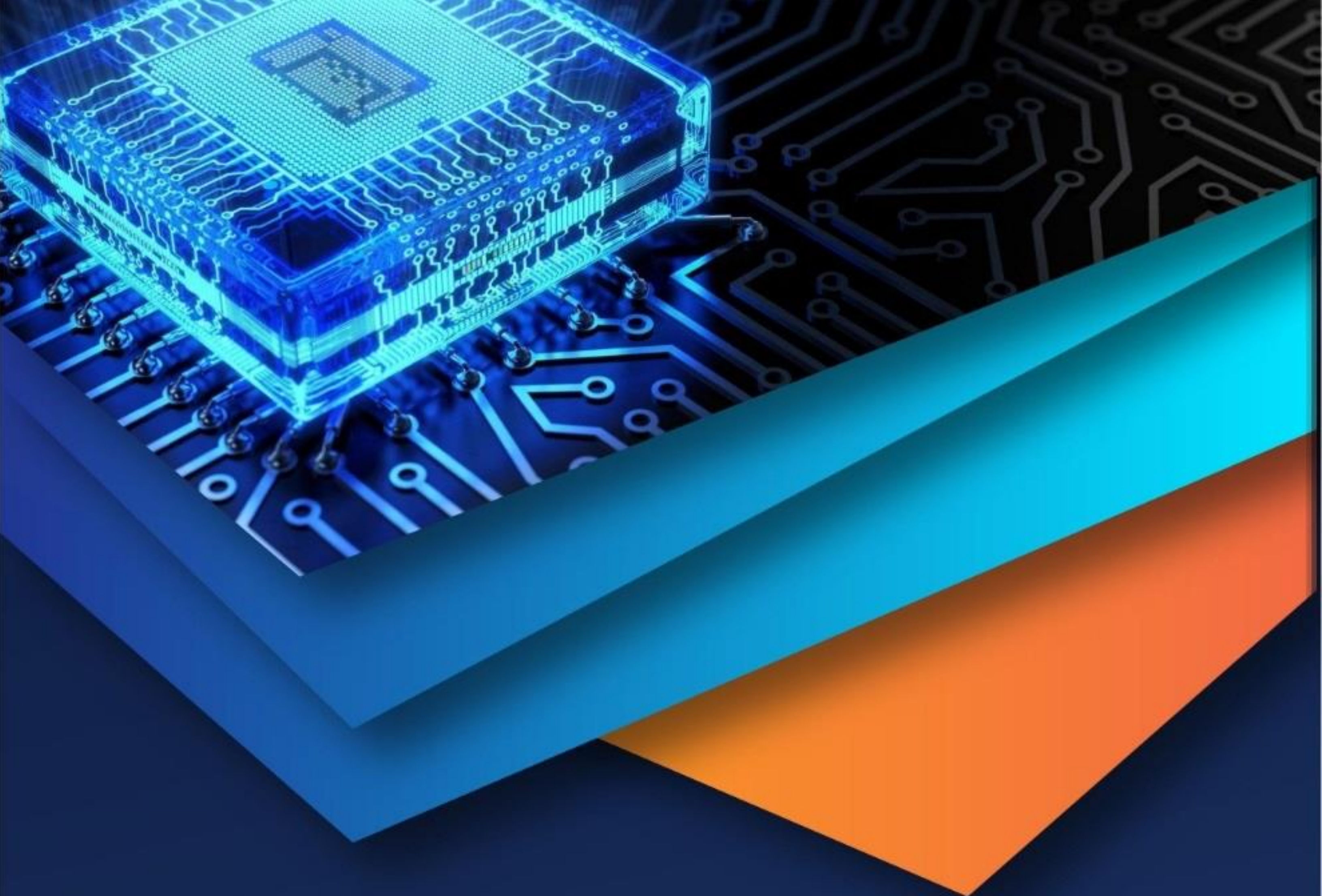

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