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Wavelet Feature based Biometric Fusion System

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***Abstract*—User verification systems that use a single biometric indicator often have to contend with noisy sensor data, restricted degrees of freedom, non-universality of the bio-metric trait and unacceptable error rates.Multimodal biometric system is expected to be more reliable than unimodal biometric systems.The employment of Zhang Suen thinning algorithm for fingerprint proves to be most efficient and the proposed algorithm showed the best results among all with regards to comparison criteria.DaugmanRubbersheet Model is preferred which finds a more precise method for iris recognition.This thesis addresses the problem of information fusion in biometric verification systems by combining information at the matching score level.The overall performance of the system has increased through Receiver Operating Characteristic curve,Equal Error Rate, False Acceptance Rate and False Rejection Rate parameters.Experimental results on combining three biometric modalities (face, fingerprint and hand geometry) are presented. The comparative study shows that accuracy in system of multimodal system is efficient than unimodal systems.**

Keywords—Face; Fingerprint; Fusion; iris; Multimodal biometrics

I. INTRODUCTION

A biometric system provides automatic recognition of an individual based on some sort of unique feature or characteristic of the individual. Biometrics refers to the automatic identification of an individual based on his/her physiological traits [1]. Biometric systems are based on fingerprints, facial features, voice, hand geometry, handwriting, the retina and iris. Biometrics is derived from Bio (means life) and Metrics (means system used for measurement). This means that biometrics means technology of measuring and analyzing physiological or biological characteristics of living body for identification and verification purposes.

Biometric systems work by first capturing a sample of the feature for example taking a digital color image for face recognition or recording a digital sound signal for voice recognition or taking fingerprint samples of fingers. Then some sort of mathematical functions are applied on the samples. The biometric template will provide an efficient and highly discriminating representation of the feature. In order to determine identity these features can be compared with other templates. Mostly biometric systems use two modes of operation. First is enrolment mode which is used for adding templates to a database and second is identification mode in which a template is created for an individual. Physiological biometrics and behavioral biometrics are two types of biometrics. Fingerprint recognition, facial recognition, hand geometry, iris recognition and DNA are examples of physiological biometrics where as speaker recognition, signature, keystroke and walking styles are examples of behavioral biometrics.

A. Uni-modal Biometric Systems

In unimodal biometric systems we face a variety of problems such as noisy data, intra-class variations, restricted degrees of freedom, non-universality, spoof attacks, and unacceptable error rates [2]. The limitations imposed by unimodal biometric systems can be overcome by using multiple sources of information for establishing identity. Such systems are known as multimodal biometric systems. These systems are more reliable due to the presence of multiple independent pieces of evidence. These systems are able to meet the performance requirements of various applications. They address the problem of non-universality, since multiple traits ensure sufficient population coverage. Spoofing is not possible in multimodal biometric system because it would be difficult for an impostor to spoof multiple biometric traits of a genuine user simultaneously.

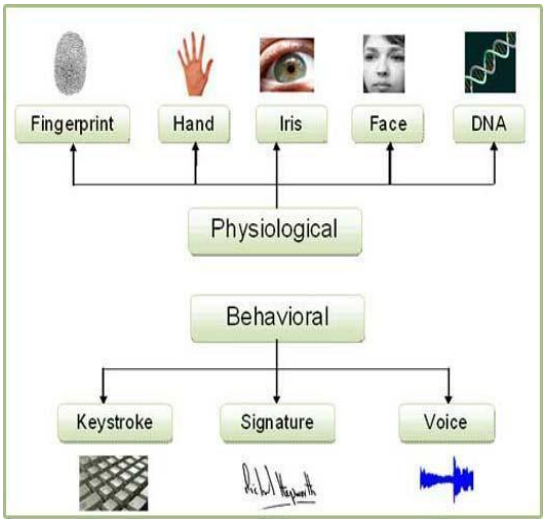

Fig. 1. Types of Biometrics

This figure defines two types of biometric systems.

B. Multimodal Biometric Systems

Multimodal system is a combination of two or more than two biometric traits of an individual for the identification purposes. Use of multimodal biometric system provides high security as compared to uni-modal biometrics. As multimodal biometric systems are better than uni-modal biometric systems we can use following three traits to form a multimodal biometric system. In contrast, multi-modal biometric systems combine information from its component modalities to arrive at a decision [3]. Several studies [4-8] have demonstrated that by consolidating information from multiple sources, better performance can be achievedcompared to the individual unimodal systems.

II. RELATED WORK

Several approaches have been proposed and developed for multimodal biometric authentication system. In 1993, John G Daugman [9] was the first who proposed the Iris Recognition algorithm in 1990s and got US patent for his work. His algorithm comprises of four steps –1) Segmentation of the Iris, Pupil in the Eye image using IntegroDifferential Operator.2) Normalization by Rubber Sheet Model. 3) Feature Extraction using the 2-D Gabor Filter. 4) Code Matching using the XOR Operation and Hamming Distance calculation. He used 592 images taken from the database provided by Ophthalmology Associates of Connecticut to test his algorithm. His results showed that it can search and match 4000 images in just 1 second including the decision making.In 2003**,**Arun Ross and Anil Jain [10] proposed an approach to address the problem of information fusion in biometric verification systems by combining information at matching score level.Experimental results on three modalities face,finger and hand suggest that the sum rule performs better thandecision tree and linear discriminant classifiers. The FAR of tree classifier is 0.036%and FRR is 9.63%. The FAR of linear discriminant classifier is 0.47% and FRR is 0.00% whereas the sum rule that combines three scores have FAR of 0.03% and a FRR of 1.78%.In 2003, J.Fierrez-Aguilar, J.Ortega-Garcia [11] proposed a system which compare aselection of fusion strategies using a mono-modal baseline systems template based face, minutiae based fingerprint and HMM based on-line signatureverification systems on MCYT multimodal approach. A new strategy of Support Vector Machine (SVM) was proposed. The results of EER for face, online signature and fingerprint verification system were11.5%,4.8% and 2.6%, by sum rule it reduced to 1% and by SVM fusion strategy, performance gone better having EER 0.03%. In 2004, J.Fierrez Aguilar, N Alonso-Hermina[12] proposed an offline signature verification systembased on fusion of two machine experts i.e. global image analysis and local image analysis(Hidden Markov models).The experimental results are given on large MCYT signature database concludes that the machine expert based on local information is shown to outperform the system based on global analysis. In 2005, Robert Snelick, UmutUludag [13] explained the performance of multimodal biometric authentication systems using state of the art commercial off the shelf (COTS) fingerprint and face matchers in 1000 individuals. The experimental results shows that COTS based multimodal fingerprint and face biometric system can achieve better performance than unimodal COTS systems. In 2005, Marcos Faundez-Zanuy [14] proposed that any biometric system cannot warranty 100% identification rates, or 0% FRR and FAR. [14] Summarizes different data fusion levels results. The experimental result yields a 1% FAR and 1% FRR, for single system but combined system yields 0.0882% FAR and 0.002% FRR. In same year, KalyanVeeramacheneni, Lsa Ann [15] proposed an evolutionary approach to sensor management of a biometric security system that improves robustness. The evolutionary nature of adaptive, multimodal biometric management (AMBM) allows reacting in pseudo-real time to changing security needs, focusing on system accuracy. In 2005, Sarat C Dass, KarthikNandakumar [16] proposed a multimodal biometric system which combine the matching scores from multiple modalities by two approaches, the product rule and copula models. The experimental results on MSU and NIST multimodal databases shows that both fusion rules achieve high performance compared to single best modality by passes the need to perform score normalization and choosing optimal combination weights for each modality on case by case basis. In same year 2005,Anil Jain and KarthikNandakumar[17] examines the effect of different score normalization techniques on the performance of multimodal biometric system. The recognition performance of a multimodal biometric system that uses face, fingerprint and hand geo-traits is improved by normalization of scores prior to combining them. Superior GAR is obtained by Min-Max, Z score and tan h normalization techniques and robustness also increased. In 2006, Hunny Malhotra, AjitaRattani [18] proposed a model of fusion of two biometric traits i.e. iris and fingerprint, at matching score level architecture using weighted sum of score techniques. The experimental results give an overall accuracy of 96.04% with FAR of 1.58% and FRR of 6.34% showing increase in accuracy by combining two biometric traits. In 2009, a secure multi-biometric fusion was done by NageshKumar and Mahesh.PK. [19] where authentication method for multimodal biometric system identification using two traits i.e. face and palm-print, fusion by matching score level architecture was proposed. At FAR of 4.5% for face and 1.5% for palm-print, FRR obtained for face and palm-print are 8.7% and 2.0%.The accuracy for face and palm-print were 97% and 96% but the overall accuracy after fusion is more than 97% whereas FAR and FRR were 2.4% and 0.8% respectively. In 2010,Le Hoang Thai and Ha Nhat Tam [20] discuss the standardized fingerprint model which is used to synthesize the template of fingerprints. The synthesizing fingerprint model consists of four steps. These are, a) Preprocessing, b) Finding and adjusting parameter sets c) Synthesizing fingerprints, d)Post processing. They used FVC2004 (DB4) fingerprint database for their research. They have done 800 synthesizing, 2800 matching between consistent and 79200 matching between inconsistent pairs to estimate the distribution of genuine and imposter matching respectively. The experiment results are compared to another results based on approach of XipingLou, 2000. FAR (fault acceptance ratio) of this model is very less as compares to XipingLou's model. In Jan 2013,Dinakardas CN *et al*[21].In this research they discuss a multimodal system in which they use PCA (Principal component analysis), Fisher face projection, minutia extraction and LBP (Local Binary Pattern)

for Face, Fingerprints and Iris traits. They use two different methods to compare the results. In first method PCA is used to extract the features of fingerprint and iris and fisher-face is used for the face image. In second method fisher-face is used for face, minutiae extraction for fingerprints and LBP feature for iris image. The performance of the system was tested on real time database which consists 500 images of iris, fingerprints and face. They compare PCA and PCA with Fisher-face technique in terms of sensitivity and from there results it shows that PCA with Fisher-face works more efficiently the PCA. In 2012, Dr. Vinayak Ashok Bharadi [22] proposed Feature vector generationusing Walsh, DCT, Hartley, Kekre Transform &Kekre Wavelets.They had enrolled total 100 persons in the database, 6 palmprints per person are used for training. Total 358 tests were performed for intra class matching and 2491 tests were performed for inter class matching. Similar method was followed for other biometrics also. Multi-instance feature vector gave best performance; Walsh transform based feature vector gave highest accuracy followed by DCT &Kekre Wavelets. Results indicate the effectiveness of the feature vector for biometric authentication.In [23] MrinalKantiBhowmik, DebotoshBhattacharjee proposed fusion of visual and thermal imagesin wavelet transformed domain has been presented. ThereDaubechies wavelet transform, called as D2, coefficientsfrom visual and corresponding coefficients computed in thesame manner from thermal images were combined to getfused coefficients. The efficiency of the scheme had beendemonstrated on IRIS thermal / visual face databasewhich contains images gathered with varying lighting,facial expression, pose and facial details. The system had achieved a maximum recognition rate of 100% in fourdifferent cases with an overall recognition rate of 85%. In 2013, S. Anu H Nair, P.Aruna&M.Vadivukarassi[24]proposed way to implement feature level fusion for the extracted images of the different biometric features. Discrete Wavelet Transform (DWT) and Discrete Cosine Transform (DCT) are used for feature extraction of face and iris. The performance of DCT and DWT are evaluated using PSNR and DWT analysed as the best feature extraction technique. The fused image can be further used for watermarking and authentication purposes.In 2012, Ravi J, K B Raja[25]proposed Hybrid Domain Based Face Recognition System (HDFRS) for different databases. The original face image is resized to uniform dimensions of 2p x 2q. The DT-CWT of a signal $x(n)$ is constructed usingtwo critically-sampled DWTs in parallel with same data. The five levels Dual-Tree Complex Wavelet Transform (DT-CWT) is applied on face image to obtain DT-CWT coefficients. The matrix of DT-CWT coefficients is segmented in to 3x3 matrixes. TheLocal Binary Pattern (LBP) algorithm is applied on each 3x3 matrix to get final features. The Euclidean Distance (ED) is used to compare features of test face image with data base images. It is observed that the values of False Rejection Rate (FRR), False Acceptance Rate (FAR) and Total Success Rate (TSR) are better in the proposed model compare to existing method.In(2013),S. Hma Salah, H. Du, and N. Al-Jawad [26] presents a fusion scheme that uses block-based uniformlocal binary patterns and Haar wavelet transform to combine localand global features We applied the principal component analysis on the fused features and managed to reduce the dimensionality of the feature space from 536 down to around 15 without sacrificing too much accuracy. We have conducted a number of preliminary experiments using a collection of 746 subject face images. The experiment results show good level of accuracy for identification. The use of PCA reduces the dimensionality of the feature vector space greatly without sacrificing much accuracy.In 2015, Cammy Singla and Naveen Goyal [27] paper presented a review of multibiometric systems including its recognition technologies, level of fusion and feature extraction for fingerprint and iris. Features like minutia points from fingerprint and texture from iris were extracted.From the study, it revealed that, performance of multibiometric systems can be further improved if an appropriate fusion strategy is used especially for the system which executed in uncontrolled environment. In 2013, Gurdeep Singh and Naveen Goyal [28] presented a paper on gray scale image using Contourlet Transform.In first section of paper process was defined. In second section, Contourlet transform was defined, algorithm was defined in third section, analysis of performance evaluation was defined in fourth section, results and conclusions in next two sections.Thenovel Algorithm gave promising results in all test cases.

III. PROPOSED WORK

A. *Individual Recognizers*

Iris, fingerprint and face biometrics perform better as compare to other available traits due to their accuracy, reliability and simplicity. The process starts with preprocessing of acquired images. Further features are extracted for training and testing images and matched to find similarity between feature sets. The matching scores generated from individual recognizers are passed to decision module where a person is declared as genuine or an imposter.

B. *Iris Recognition*

Due to many colors, iris is called as “Goddess of the Rainbow”, which is a Greek word. The thin portion between the dark pupil and white sclera is iris. In human eye iris is the colored part which is placed behind the cornea. Each eye has unique iris because two irises are never having same mathematical function details. The identical twins and triplets also having different iris’s patterns. Even one's own left and right eye irises are different. From this, it shows the uniqueness of the iris and hence it can be used for the identification purposes. The important steps involved in iris recognition are:

- Segmentation using Canny’s Edge Detector
- Normalization using Daugman Rubber-sheet Model
- 2D wavelet transform for feature extraction
- Matching

a) Segmentation using Canny’s Edge Detector- Segmentation is done to find the inner and outer edge of iris region. The proposed system uses Canny Edge Detection algorithm to find the edge of the given person’s eye. Canny [29] in 1986 proposed an edge detection algorithm. This optimal detector has a

simple approximate implementation in which edges are marked at maxima in gradient magnitude of a Gaussian-smoothed image. The raw image is convoluted with a Gaussian filter to remove noise in the image due to lighting effects produced during capture process. The result obtained is a slightly blurred version of the original image which is not affected by a single noisy pixel to any significant degree of freedom. The further step is finding the gradient of the image. Edge gradient (G) and direction; (Q) is determined from eqn. (1) and eqn. (2).

$$Edge\ Gradient, G = \sqrt{Gx^2 + Gy^2} \quad (1)$$

$$Direction, Q = \arctan \frac{Gx}{Gy} \quad (2)$$

As a result of suppression of non-maximum, different set of edge points in the form of a binary image is obtained. Finally edge is traced in this non maximum suppression. Two thresholds are chosen to trace the edges. Applying a high threshold value of thresh H, the system marks out the genuine edges. After starting from these edges, using the directional information derived from Eqn. 3, edges can be traced throughout the image. Applying the lower threshold value threshold L, traces the faint sections of edges.

$$MS_{Iris} = \frac{1}{N}\sum_{i=1}^{N} A_i + B_i \quad (3)$$

Inner edge of iris can be obtained by selecting two appropriate numbers that are indicated to two upper and lower thresholds (L, U). The intensity of each pixel is converted to 0 if the intensity is lower than L+K, convert it to 255 if the intensity is bigger than U – K. Otherwise the intensity is filtered to lower one by use of scaling factor. The process is verified and the inner boundary is located. Morphological operator, Extended Minima (EM) transform is used to detect outer boundary of the iris detection region [30]. EM transform is always the region of minima of the H-minima transform. H-Minima transform suppresses all minima in the intensity image whose depth is less than a scalar. By choosing an appropriate scalar in EM transform, a perfect edge of outer boundary is gotten.

A robust algorithm for pupil center detection [31] using radial symmetry transform was proposed by Bei Yan. This proposed system uses the following technique to compute coordinates and radiuses of the segmented iris images. The morphological operations, clean operation removes the isolated pixels which come in picture, spur operation is the operation used to remove spur pixels, fill operation fills isolated interior pixels, are applied to the binary image described. Label the connected components of the binary image. The image's labeled pixels that are equal to I are found as a result. Then, the size of the connected components is computed. The process is repeated for n times to locate circles among the components. The pupil center is marked and radii found.

b) Normalization using Daugman Rubber-sheet Model-Daugman's [32] remap the each point of iris region to a polar coordinates, (r) where r is in the range of [0, 1] and $\boldsymbol{\theta}$ is of range [0,2pi]. The remapping of coordinates is done from circle's x and y coordinates it converts the co-ordinates into the polar coordinates.

$$R = ag \pm ag2 - a - r2 \text{ where a}=\sigma_x^2 + \sigma_y^2 \quad (4)$$

$$g = \cos\{\rho i - \tanh-(\sigma x2 + \sigma x1)\} \quad (5)$$

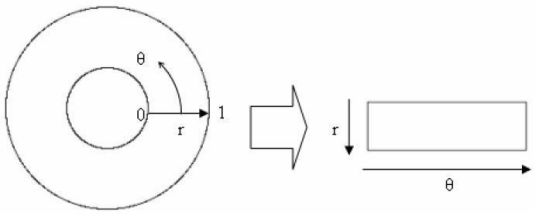

Fig. 2. Daugman Rubbersheet Model

c) 2D wavelet transform for feature extraction-For feature extraction, normalized eye pattern is convolved with 1D wavelets to extract bits of iris information. The Hamming distance is generated by sum of bits of two iris templates divided by total number of bits that are used to compare biometric templates of eye image described. Ideally, two biometric templates of same iris image would generate 0 hamming distance but sometimes error occurs during segmentation which make hamming distance to be non-zero.

d) Matching-The comparison is done between iris codes (IC) generated for database and query images using hamming distance approach. In this hamming approach the difference between the bits of two codes are counted and the number is divided by the total number of comparisonswhere A is the binary vector (iris code) for database image and B is the binary vector for query image while N is the number of elements. This matching score (MS_{Iris})is used as input for the fusion module where the final matching score is generated.

C. Fingerprint Recognition

Recently fingerprint recognition is becoming automated (i.e. a biometric) due to advancements in computing capabilities. Due to versatility of fingerprint biometrics, these are applicable in almost all areas which require clear identification. Fingerprints are distinct to each person because of unique papillary features. The systematic study on the ridge, valleys, furrow, and pore structure of fingerprints has been published in [33]. The use of minutiae features for single fingerprint classification. A system on fingerprint

classification is discussed in [34]. The important steps involved in fingerprint recognition are:

- Image Enhancement
- ZHANG-SUEN's thinning algorithm
- 2D Wavelet transform for feature extraction
- Matching

a) Image Enhancement-A fingerprint image is corrupted due to various kinds of noises such as smudges, creases and holes. It is almost impossible and very difficult to recover the true ridge/valley structures from the unrecoverable regions; any effort to improve the quality of the fingerprint image in these regions may be futile. Therefore, need of a well-known enhancement algorithm may be used to improve the clarity of ridges/valley structures of fingerprint images in recoverable regions and to mask out the unrecoverable regions. After enhancement technique from normalized image enhanced image is obtained.

b) ZHANG-SUEN's thinning algorithm-Fingerprint image thinning is a very important step in fingerprint recognition algorithms. In this step the ridgelines of the fingerprint image are transformed to a one pixel thickness. This process is fundamental for fingerprint recognition algorithms [35], as thinned images are easier to process, and reduce operations processing time. As thinning does not change the structure of the fingerprint image

The algorithm works using a 3x3 sized block. It is an iterative algorithm and it removes all the contour points of the image except those that belong to the skeleton. The algorithm is divides into two sub-iterations [36].The algorithm is describes below:

1. While points are deleted, do
2. for all p(i, j) pixels, do
3. if

ι. $2<(\Pi 1)<6$ (6)

A(P1) = 1
One of the following is true:
P2 x P4 x P6 = 0 in odd iteration,
P2 x P4 x P8 = 0 in even iteration,
One of the following is true:
P4 x P6 x P8 = 0 in odd iteration,
P2 x P6 x P8 = 0 in even iteration,
then
3. Delete pixel p (i, j).
where A(P1) is the number of 0 to 1 transitions in the clockwise direction from P9, B(P1) is the number of non-zero neighbors of P1:

B(P1)=summationPi (i=2,2<I<9,i=9) (7)

P1is not deleted, if any of the above conditions are not met. The algorithm is fast, but fails to preserve such patterns that have been reduced to 2x2 squares. They are completely removed. It also has problems preserving connectivity with diagonal lines and identifying line endings.

c) 2D Wavelet transform for feature extraction-The enhanced fingerprint image is binarized and submitted to the thinning algorithm which reduces the ridge thickness to width of one pixel. For feature extraction of minutiae points eight connected pixels are used [37]. The Crossing Number (CN) method is used to perform minutiae extraction. This feature extraction method extracts the ridge endings and bifurcations from the skeleton image by examining the local neighborhood of each ridge pixel using a 3×3 window. The CN for a ridge pixel P is given by

$$\Pi_9 = \Pi_1 \quad (8)$$

Where Pi is the pixel value in the neighbor of P. After the CN for a ridge pixel has been founded, the pixel can then be categorized according to its CN value. A ridge pixel with a CN of one features to a ridge ending, and a CN of three features to a bifurcation. For each and every extracted minutiae point, the following information is recorded:
•x and y coordinates,
•orientation of the associated ridge segment, and
•type of minutiae (ridge ending or bifurcation)

d) Matching-The database and query fingerprints are used for minutiae feature extraction and stored as points in the two dimensional plane. A minutia extraction based matching essentially consists of finding alignment between the template and the input minutiae sets that results in the maximum number of minutiae pairings. Let A = {m1……mm} and B = {m1…….m n} be the set of minutiae points extracted from database and query images respectively. Where m={x, y, θ}, x and y are the coordinates at particular minutiae point and θ is the orientation. The two sets are combined using

$$sd = \sqrt{(x_j + x_i)^2 + (y_j - y_i)^2} \le r_o \quad (8)$$

$$dd = \min[(\theta_j^{'} - \theta_i), 360 - (\theta_j^{'} - \theta_i) \le \theta_o] \quad (9)$$

D. Face Recognition

The least intrusive and fastest biometric technology is the face recognition. This technology works with the recognition of human face. Unlike other recognition system in which people need to place their hands on a reader or precisely position their eye in front of the scanner, face recognition system takes picture of people's face as they enter a defined area of face. A digital video camera is used to analyze the characteristics of a person's face in face recognition system and the image of person is used as an input to the video camera. It measures all the parameters related to facial structure like distance between eyes, nose, and mouth and jaw edges. A database is used to store all these measurements and when a user stands before the camera, these are used for the comparison. There are

approximately 80 nodal points in each human face. Every human face has different peaks, valleys and distinguishable landmarks which make up facial features.

E. Score Generation

These are the scores generated from iris, finger and face traits. In score normalization, matching scores between 0 and 1for 3 biometrics is calculated as under

$$N_{Iris} = \frac{MS_{Iris} - \min_{Iris}}{\max_{Iris} - \min_{Iris}} \quad (10)$$

$$N_{Finger} = \frac{MS_{Finger} - \min_{Finger}}{\max_{Finger} - \min_{Finger}} \quad (11)$$

$$N_{Face} = \frac{MS_{Face} - \min_{Face}}{\max_{Face} - \min_{Face}} \quad (12)$$

Where andare the minimum and maximum scores for iris recognition and are the corresponding values obtained from fingerprint trait and andobtained from face modality.

F. Fusion

The three normalized similarity scores N_{Iris}, N_{Finger} and N_{Face} are fused linearly using sum rule as

$$MS = \alpha * N_{Iris} + \beta * N_{Finger} + \delta * N_{Face} \quad (13)$$

where α, β and c are two weight values that can be determined using some function. Here we use combination of linear and exponential function. The value of weight is assigned linearly if the value of matching score is less than the threshold; otherwise exponential weightage is given to the score. The value of MS is used as the matching score. So if MS is found to be more than the given threshold value the candidate is accepted otherwise it is rejected.

IV. EXPERIMENTAL RESULTS

The following chapter describes the result tested on iris, fingerprint and face images collected by authors. The database consists of three iris images of each subject,3 fingerprint images of each subject and 5 face images of each subject with total 18 subjects and total 198 images has been tested. The fingerprint images are taken using optical fingerprint scanner. The iris and face images are taken using digital camera. The images are acquired in are solution of 200*200 sizes. Our multibiometric system is implemented in MATLAB 2012a on a Dual Core Window8.The preprocessed images of iris, fingerprint and face are fused at matching score level.The overall performance of the system has increased showing EER of 0.0858, FAR of 0.7383 and FRR of 0 respectively as shown in table 1.Table 2 shows the area under ROC curve (Az) of 0.9938, Standard Deviation of 0.0092 and 95% Confidence Interval of 0.9688.The receiver operating characteristics (ROC) can judge the performance of the system by describing about interaction between imposters and genuine. The ROC is plotted false positive rate (specificity) against true positive rate (sensitivity). Most verification methods output a score for each access of system.

TABLE I. PARAMETER NAMES AND VALUES

Parameters	Existing system 1	Existing system 2	Proposed system
Az	0.96096	0.96208	0.9938
S.D	0.01393	0.01373	0.0092
95% CI	0.93365	0.93516	0.9688

TABLE II. FIGURE SHOWING PARAMETER NAMES AND VALUES

Parameter Name	Parameter Value
FAR	0.7383
FRR	0
EER	0.0858

On selecting a threshold over which biometric scores are taken genuine clients instead of impostors can greatly modify the relative performance of FAR and FRR both ratios. A typical threshold recognized is the one that follows the Equal Error Rate (EER) where FAR=FRR on a separate validation set.

Another method to recognize the performance of overall system is by the use of the so-called ROC curve, which defines the FAR as a derived function of the FRR. A more interesting and valuable fact to design is of the plot is the DET curve, which is a transformed version of the ROC curve defined which is nonlinear also in order to make easier to compare the results. The non-linearity is actually a normal deviate, which comes from the hypothesis that the normal scores of client accesses and impostor accesses follow a distribution called Gaussian distribution. If this hypothesis is true, the DET curve must be a line function. Figure 3 shows examples of DET curves is as shown.

An identity verification system has to check out two kinds of events: either the person claiming a given identity is the one who actually he claims to be (in this case, he is called a client), or he is not (in which case existed, he is known an impostor). Moreover, the system or architecture may generally take two decisions: either accept the client or reject him and decide to be an impostor. Thus, the system may make two types of errors: false acceptances (FA), when the system accepts an impostor user, and false rejections (FR), when the system rejects a client user. In order not to get dependent on the specific dataset distribution, the performance of the system outcome is often measured in terms of these two different errors (FAR and FRR) as defined above.Most verification systems output a score for each access. On selecting a threshold over which biometric scores are taken genuine clients instead of impostors can greatly modify the relative performance of FAR and FRR both ratios. A typical threshold

chosen is the one that reaches the Equal Error Rate (EER) where FAR=FRR on a separate validation set. Another method to evaluate the performance of a system is through the use of the so-called Receiver Operating. Characteristics (ROC).

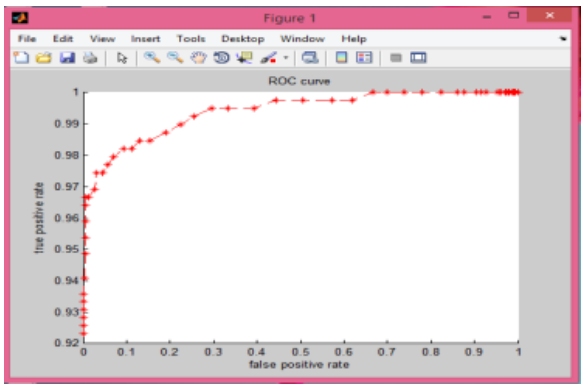

Fig. 3. Receiver Operating Characteristic Curve

The overall performance of the system has increased showing EER of 0.0858, FAR of 0.7383 and FRR of 0 respectively as shown in table 1.These parameters are compared with existing systems as shown in table 3,4 and 5.

TABLE III. SHOWING COMPARISON OF FAR WITH EXISTING SYSTEMS

Systems	FAR,%
HunnyMehrotra et al [18]	1.58
R. Gayathri et al. [39]	1.6
Nageshkumar.M et al. [19]	2.4
A Rattani et al. [38]	4.95
Hybrid Proposed system	0.7383

TABLE IV. SHOWING COMPARISON OF FRR WITH EXISTING SYSTEMS

Systems	FRR,%
HunnyMehrotra et al [18]	6.34
Arun Ross et al [3]	1.78
Marcos et al [14]	0.0002
R. Gayathri et al. [39]	0.8
Nageshkumar.M et al. [19]	0.8
A Rattani et al. [38]	1.12
Hybrid Proposed system	0

TABLE IV SHOWING COMPARISON OF EER WITH EXISTING SYSTEMS

Systems	EER,%
Davrondzhon et al. [40]	5,9
J.Fierrez et al. [11]	0.3
Ailisto et al.[41]	6.4
Mantyjarvi et al. [42]	7,10,18,19
Gafurov et al. [43]	16
Hybrid Proposed system	0.0858

The threshold curve defines the distribution of genuine, imposter and both genuine imposter together with respect to density along with hamming distance.

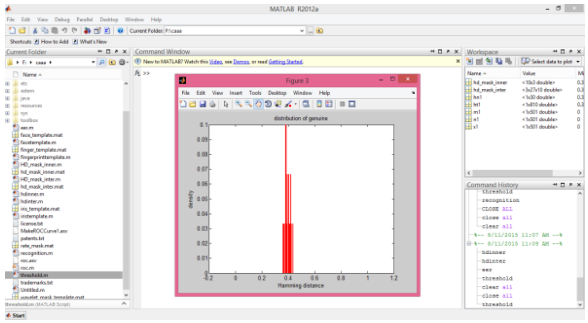

Fig. 4. Threshold Curve for Genuine.

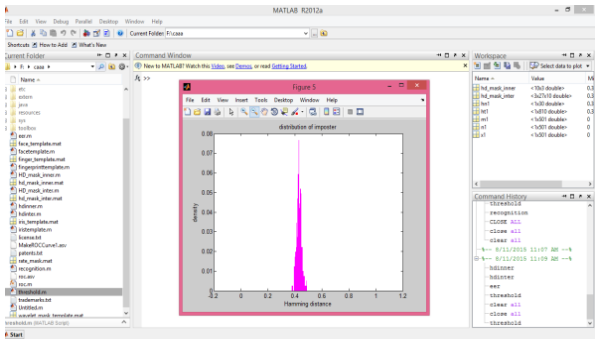

Fig. 5. Threshold Curve for Imposter

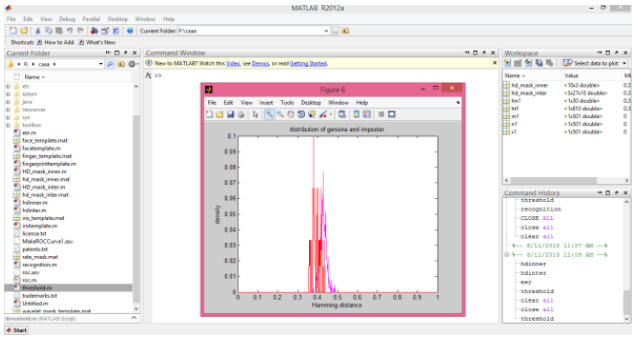

Fig. 6. Threshold Curve for Genuine and Imposter

V. CONCLUSIONS

Multimodal biometric system is expected to be more reliable than unimodal biometric systems. Based on the study of multimodal biometric system, the features of face, iris and fingerprint are extracted separately using different algorithms. The database consists of three iris images of each subject,3 fingerprint images of each subject and 5 face images of each subject with total 18 subjects and total 198 images has been tested. DaugmanRubbersheet Model is preferred which finds a more precise method for iris recognition. We conclude that our proposed iterative segmentation algorithm using canny edge detector is successive in detecting the border of eyelashes, even we also conclude that its performance is more reliable than segmentation using other algorithms. The employment of Zhang Suen's thinning algorithm for fingerprint proves to be most efficient and the proposed algorithm showed the best results among all with regards to comparison criteria. This thesis addresses the problem of information fusion in biometric verification systems by combining information at the matching score level.

The experimental results shows that accuracy in system of multimodal system is efficient than unimodal systems. The experimental results demonstrate remarkable improvement in the accuracies by properly fusing feature sets. The experimental results demonstrate that fusing information from independent uncorrelated sources (iris, face and fingerprint) at the matching score level increases performance. The performance analysis of our proposed method outperformed the previous one. Our study has proposed quantative data to demonstrate the relative performance levels, the terms of ROC curve.

VI. FUTURE SCOPE

The fused image can be further used for watermarking and authentication process. Future experiment on standard multimodal databases, will allow bettering validating the system performances. The benefits of multi biometrics may even more evident in case of larger database of users. The automatically updating of the biometric templates of a user can be further in process through fused images. Thus, future plans include expanding the test databases to attain these larger sizes. In addition, to assess the feasibility of such systems for large-scale deployments, we will perform these tests using COTS products. On Summarizing or on evaluating overall performance we can say that the biometrics systems are effective for human identification or verification and authorization over various levels of implementation, for small to a large user population, such systems are not easy to forge and can be made for secure by combining more than one biometric traits or modalities , that is multimodal biometric systems. Such multi modality systems will become ubiquitous and inevitable in the coming future.

We can expect more robust, effective and accurate biometric system for the near future. Very little research has been conducted on biometric sensor interoperability. More research is needed to clearly understand how the use of different sensors for enrolment and verification affects system accuracy. Finding the most effective way to fuse independent subsystem opinions into a more accurate decision to improve system accuracy is a significant research challenge. More research is needed to understand how one biometric measurement from an individual is related to another biometric measurement of the same person.

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