ISSN: 2277-3754
ISO 9001:2008 Certified
International Journal of Engineering and Innovative Technology (IJEIT)
Volume 2, Issue 1, July 2012

Biometric Recognition Systems-Multimodal over Unimodel

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Abstract: - Biometric recognition system gained superb popularity because of its uniqueness and wide applications. Uniqueness lies in the factor that each and every human being's biometrics features are unique and inevitable. Most of the present researcher deals with improvement of these biometric systems, in a way that either the feature extractions from the image become good or matching of the feature becomes exact. Single modality biometric recognition systems are usually result degraded performance because of erroneous/modified pattern, for example finger print recognition system delivers problem due to scratched, wet, colored or tattooed fingers. In the similar manner 2D images/patterns of face recognition system can dramatically change due to lighting and viewing variations. Hence, in the recent past years, scientist/researchers combined biometric recognition system to improve the recognition performance.

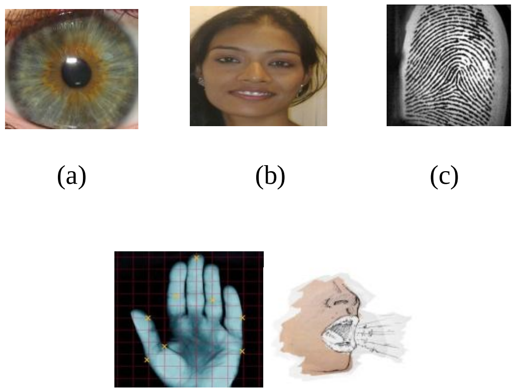
Keywords: **Biometric, Fingerprint Recognition, CN, Face Recognition, Doubly Nonlinear Mapping, Face Recognition, Gabor Wavelets, Kernel Principal Component Analysis (KPCA). Features Extraction, Fusion, Multimodal Biometrics.**

I. INTRODUCTION

The biometric is the study of physical or behavioral characteristics used for the identification of a person [1]. These characteristics of a person include the features like fingerprints, face, hand geometry, voice, and iris biometric features. These biometrics features can be used for authentication purpose in computer based security systems. The identification of a person is becoming highly important as the ID cards, punch, secret password and PIN are used for personal identification [2] .The ID can be stolen; passwords can be forgotten or cracked. The biometric identification overcomes all the drawbacks. Additional security barriers can be provided using any one of the biometrics features [3]. It is the primary thing to provide security to the information present on internet. For this purpose the confidential authentication is required by replacing the username and password [4].The biometric systems offer several advantages over traditional authentication systems. They are required the person being authenticated to be present at the point of authentication [5]. Thus biometric-based authentication method is most secure system. For many applications the system uses the password as well as biometrics for authentication.

A. BIOMETRICS

The physical characteristics of a person like finger prints, hand geometry, face, voice and iris are known as biometrics. Each biometric trait has its strengths and weaknesses. The important features of the various biometrics are discussed briefly in this section.



(a) (b) (c)

(d) (e)

Fig.1: Biometrics
a) Iris (b) Face (c) Fingerprint
(d) Hand Geometry (e) Voice

1. Finger Prints

The finger prints of a person have been used as person identification from long time. A finger print is the pattern of rids and valley on the surface of a finger tip. This method is traditional geometry is scanned as shown in figure 1(b) and used for identification and recognition of a person.

2. Hand Geometry

The hand geometry recognition systems are based on a number of measurements taken from the human hand, including its shape, size of palm, length and width of the fingers. This method is very simple and easy to use. Also hand geometry information may not be invariant during the growth period of the children [6].

3. F**ace**

The face is the commonly used biometric characteristics for person recognition. The most popular approaches to face recognition are based on shape of facial attributes, such as eyes, eyebrows, nose, lips, chin and the relationships of these attributes. All these attributes of the face image are shown in figure 1 (c) .As this technique involves many facial elements; these systems have difficulty in matching face images [7]. This face recognition system automatically detects the correct face image and is able to recognize the person.

4. **Voice**

The voice recognition systems have been currently used in various applications. Voice is a combination of physical and behavioral biometrics. The figure 1 (d) shows a sample speech signal. The features of person voice are based on the vocal tracts, mouth, nasal activities and lips movement that are used synthesis of sound. The speaker dependent voice recognition systems are text

ISSN: 2277-3754
ISO 9001:2008 Certified
International Journal of Engineering and Innovative Technology (IJEIT)
Volume 2, Issue 1, July 2012

dependent; and the speaker independent systems are what he or she speaks.

5. Iris

The iris is biological feature of a human. It is a unique structure of human which remains stable over a person lifetime. The iris is the annular region of the eye. The left and right irises of an individual can be treated as separate unique identifier. A sample human eye image is given in figure 1 (e).The iris information can be collected by iris image. The accuracy of iris based recognition system is promising. Each iris is believed to be distinctive and even the irises of identical twins are also different [9].

B. Biometric Recognition System

The Biometric Recognition Systems are used to identify the person based on the feature vectors of any one of the biometric that the person possesses [10]. The computer based security systems are used in various commercial, civilian and forensic applications. Each person has to establish the identity ranging from drivers' license to gaining entry into a country to the passport. The biometric system uses the individual's physical characteristics like fingerprint, hand geometry, face, voice or iris. A simple biometric system consists of four modules: Image/Voice acquisition, Preprocessing, Feature extraction and Recognition. The proposed system should be able to collect the biometric image or voice, to perform preprocessing on original input, to encode the input to get feature vector, to match the features to recognize the person.

Table I: [11] Comparison of Biometrics
(H=HIGH, L=LOW, M=MEDIUM)

Biometric Characteristics	Universality	Uniqueness	Permanence	Performance	Measurability
Finger Print	M	H	H	H	M
Hand Geometry	M	M	M	M	H
Face	H	H	M	L	H
Iris	H	H	H	H	M
Voice	M	L	L	L	M

II. LITERATURE SURVEY

In year 2011 a paper n titled "A new human identification based on fusion fingerprints and faces biometrics using lbp and gwn descriptors" has done a multimodal biometric recognition system based on fusion of fingerprint and face, has been proposed. Fusion of these two biometric traits is carried out at a matching score. In year 2010 a paper titled "Fusion of Fingerprint and Face by using DWT and SIFT "proposed a concept that an efficient method for fusion of face and fingerprint is proposed. Proposed method first decomposes images and then fused image is produced. "Multimodal face and finger vein biometric Authentication" Multimodal has great demands to overcome the issue involved in single trait system and it has become one of the most important research areas of pattern recognition. In year 2009 "Small Sample Biometric Recognition Based on Palm print and Face Fusion" Reliability in personal authentication has not yet been solved. A multimodal biometric system based on fusion of face and different fusion methods.

III. RESEARCH METHODOLOGY

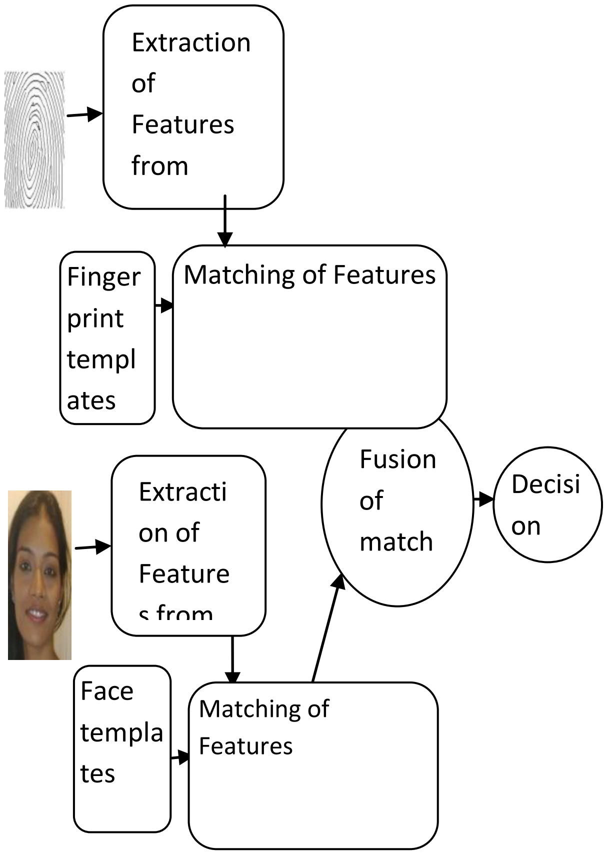


Fig. 2: Block Diagram of Fusion

A. Comparison of Biometrics

The comparison of the various biometric methods is based on the various factors. The biometric features of fingerprint, face, hand geometry, voice and iris have the characteristics like universality, Uniqueness, permanence, performance and Measurability. These characteristics are different for each biometric type. These can be measured in High, Medium and Low [3]. Any human physiological or behavioral trait can serve as a biometric characteristic as long as it satisfies the following requirements. Table 1 compares the biometric features based on different factors.

Universality: Everyone should have it.
Uniqueness: No two individuals should have the same value of characteristics.
Permanence: It should be invariant over a given period of time.
Performance: It should give accuracy and speed.
Measurability: It must be easy to measure.

B. Biometric Fusion

1. Framework of the proposed system

Fig. 2 corresponds to the block-diagram of the proposed multimodal biometric system integrating fingerprint and face. Fingerprint recognition or Face recognition all

ISSN: 2277-3754
ISO 9001:2008 Certified
International Journal of Engineering and Innovative Technology (IJEIT)
Volume 2, Issue 1, July 2012

involve image enhancement, feature extraction, matching score and final decision. In an operational phase, the two bio metric sensors are processed by the two feature extraction modules to produce a face or fingerprint recognition.[11]

2. Fusion

Scores generated from single biometric traits are combined by matching score level [12]. A variety of methods such as simple or weighted sum, min/max rules was presented for achieving the matching score level [13]. In our approach we will use simple sum.$ms_{f\,i}$and $ms_{f\,a}$ correspond to the matching scores obtained by the system of recognition of fingerprint and face respectively. The normalization of the score is the first step involved in fusion. The matching score level output obtained for the two traits are not located in the same range, so that the matching scores of different matchers are transformed into a common domain[14]. Normalization transforms the scores into a common range included between 0 and 1.

Table II.[11] Performance of proposed system based upon five factors (P1=Universality, P2= Distinctiveness,P3=Permanence,P4=Recouvrement,P5=Accessibility, H=HIGH, L=LOW, M=MEDIUM)

3 .Comparison with unimodal Methods

The evaluation of the performance of a biometric system is done by the ROC (Receiver Operating Characteristic) curves, these curves are commonly used in such fields for the decision phase to validate the proposed approach.[15] The ROC curve corresponds to a graphical visualization of the true positive rate (TP) against the false positive rate (FP) of the multimodal biometric system.

4. Finger Prints Recognition

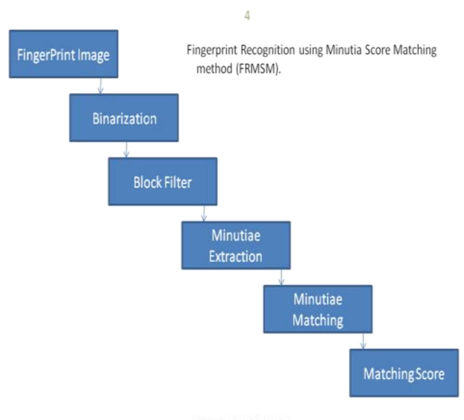


Fig. 3: Block Diagram of Fingerprint Process

Fingerprint Recognition using Minutia Score Matching Method (FRMSM) Model is discussed. And some Keywords are used:

Termination : The Location where a ridge comes to an end.

Bifurcation : Location where a ridge divides into two separate ridges.

Binarization : process of converting the original grayscale image to a black-and white image.

Thinning : process to reduce the width of each ridge to one pixel.

Termination Angle: Angle between the horizontal and the direction of the valley ending between bifurcations.

Bifurcation Angle: Angle between horizontal and direction of the valley ending between bifurcations.

False Matching Ratio : It is the Probability that the system will decide to allow access to an imposter by the equation(1)

$$FMR = \frac{\text{False Matches}}{\text{Imposter Attempts}} \qquad (1)$$

The Imposter attempts are implemented by matching each input image with all the templates.

False match was recorded for each imposter attempts when the matching score was greater than the established threshold.

False Non Matching Ratio : Probability that the system denies access to an approved user and will b measured by equation (2)

$$FNMR= \frac{\text{False Non Matches}}{\text{Enroll Attempts}} \qquad (2)$$

IJEIT
ISSN: 2277-3754
ISO 9001:2008 Certified
International Journal of Engineering and Innovative Technology (IJEIT)
Volume 2, Issue 1, July 2012

Enrollee attempts are implemented by matching each input image with corresponding template image, hence it is one-to-one matching. A False Non-match was recorded when the matching score between an enrollee and its template was less than the established threshold.

Matching Score: it is used to calculate the matching score between the input and template data is given in an equation (3)

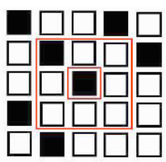
$$\text{Matching Score} = \frac{\text{Matched Minutia}}{\text{Max}(Nt,Ni)} \quad (3)$$

Where, Nt and Ni represent the total number of minutiae in the template and input matrices respectively. By this definition, the matching score takes on a value between 0 and 1. Matching score of 1 and 0 indicates that data matches perfectly and data is completely mismatched respectively [16].

Binarization: Binarization is the process of converting gray scale image into binary image. Figure 2 shows the binarized image from original image

(a) **(b)**

Fig 4(a) Original Image (b) Binary Image



Block Filter:

Binarized image is thinned using Block Filter to reduce the thickness of all ridge lines to a single pixel to extract minutiae points effectively. Thinning doesn't change the location and orientation derived. Termination points which lie at the outer boundaries are not considered as minutiae points. And based on the crossing number minutiae points are located..

(a) **(b)**

Fig.5 (a) Binarized Image (b) Thinned Image

Minutiae Extraction: After Minutiae extraction process minutiae location and minutiae angles are declared.

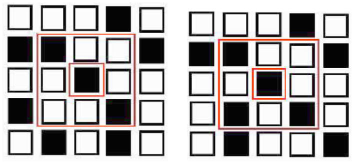
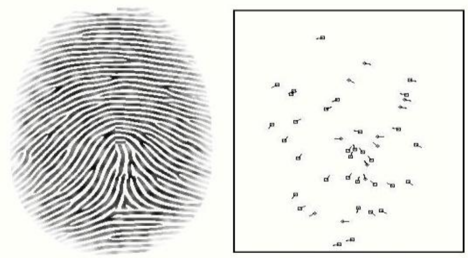


Fig. 6: Type of minutiae based on crossing number
Crossing Number= 1 Crossing number=2
Crossing number=3
Termination point Normal ridge Pixel
Bifurcation point



(a) **(b)**

Fig. 7: (a) Gray-scale Image (b) Minutiae Points

Minutiae Matching: Minutiae matching is used to compare the input fingerprints with templates. For efficient matching process, the extracted data is stored in the matrix format. The data matrix is as follows.

Number of rows: Number of minutiae points.
Number of columns: 4
Column 1: Row index of each minutia point.
Column 2: Column index of each minutia point.
Column 3: Orientation angle of each minutia point.
of minutiae points.
Column 4: Type of minutia. (A value of '1' is assigned for termination, and '3' is assigned for bifurcation).

IV. FACE RECOGNITION

Human face recognition has attracted significant attentions because of its wide range of applications [17], such as criminal identification, credit card verification, security system, scene surveillance, entertainments, etc. In these applications, face recognition techniques are used on various source formats ranging from static, controlled format photographs to uncontrolled video sequences which have been produced in different conditions.

A. Gabor Wavelets

The Gabor wavelets, whose kernels are similar to the response of the two-dimensional receptive field profiles of the mammalian simple cortical cell [18], exhibit the desirable characteristics of capturing salient visual properties such as spatial localization, orientation selectivity, and spatial frequency [19]. The Gabor wavelets can effectively abstract local and discriminating features, which are useful for texture detection [20] and face recognition [21], [22], [23].

Biometric Traits
P1
P2
P3
P4
P5
Finger Prints
Finger Prints
M
H
H
M
M
Face
Face
H
F
M
H
H
Fusion
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rollee attempts are implemented by matching each input image with corr

ISSN: 2277-3754
ISO 9001:2008 Certified
International Journal of Engineering and Innovative Technology (IJEIT)
Volume 2, Issue 1, July 2012

In the spatial domain, a Gabor wavelet is a complex exponential modulated by a Gaussian function, which is defined as follows [18], [21], [24].

$$\Psi\_(\omega,\theta)\,(u,v) = 1/(2\pi\sigma\hat{}2\ )\,e-(((u\cos\theta + v\sin\theta)\hat{}2\,2 + (-u\sin\theta + v\cos\theta)\hat{}2)/(2\sigma\hat{}2))\ .[e\hat{}i(\omega u\cos\theta + \omega v\sin\theta) - e\hat{}(-\omega\hat{}(2)\,\sigma\hat{}2)/2] \quad (6)$$

where u ,v denote the pixel position in the spatial domain, ω is the radial center frequency of the complex exponential is the orientation of the Gabor wavelet, and σ is the standard deviation of the Gaussian function. The value of σ can be derived as follows [24]:

$$\sigma = \frac{k}{\omega} \quad (7)$$

Where $k = \sqrt{2\ln 2}((2^{\phi}+1)/(2^{\phi}-1))$, and ϕ is the bandwidth in octaves. By selecting different center frequencies and orientations, we can obtain a family of Gabor kernels from(6), which can b used to extract features from an image. Given a gray- level image f(u,v),th convolution of f(u,v) and $\varphi_{\omega,\theta}(u,v)$ is given as follows:

$$y_{\omega,\theta}(u,v) = f(u,v) * \Psi_{\omega,\theta}(u,v) \quad (8)$$

Where * denotes the convolution operator. The convolution can be computed efficiently by performing the fast Fourier transform (FFT), then point-by-point multiplications, and, finally, the inverse fast Fourier transform (IFFT). Concatenating the convolution outputs, we can produce a one-dimensional Gabor representation of the input image denoted as follows:

$$Y_{\omega,\theta} = [y_{\omega,\theta}(0,0), y_{\omega,\theta}(0,1) \dots, y_{\omega,\theta}(0,N_r-1), y_{\omega,\theta}(1,0) \dots, y_{\omega,\theta}(N_c-1, N_r-1)]^T \quad (9)$$

Where T represents the transpose operation, and N_c and N_r are the numbers of columns and rows in an image. we consider only the magnitude of the output of Gabor representations, which can provide a measure of the local properties of an image [21] and is less sensitive to the lighting conditions (for convenience, we also denote it as $Y_{\omega,\theta}$). $Y_{\omega,\theta}$ is normalized to have zero mean and unit variance; and then the Gabor representations with different and are concatenated to form a high-dimensional vector for face recognition as follows:

$$Y = [Y^T_{\omega 1,\theta 1}, Y^T_{\omega 1,\theta 2}, \dots, Y^T_{\omega l,\theta n}]^T \quad (10)$$

Where l and n are numbers of center frequencies and orientations used for the Gabor wavelets.

B. Principal Component Analysis

PCA is a classical method that has been widely used for human face representation and recognition. The major idea of PCA is to decompose a data space into a linear combination of a small collection of bases, which are pair wise orthogonal and which capture the directions of maximum variance in the training set. Suppose there is a set of centered N-dimensional training samples Y_i , i = 1,2, …., M, such that $Y_i \in R^N$ and $\sum_{i=1}^{M} Y_i = 0$. The covariance matrix of the input can be estimated as follows:

$$\Sigma = \frac{1}{M}\sum_{i=1}^{M} Y_i Y_i^T \quad (11)$$

The PCA leads to solve the following eigenvector problem:

$$\lambda v = \Sigma v \quad (12)$$

Where, v are the eigenvectors of Σ , and λ are the corresponding eigenvalues. These eigenvectors are ranked in a descending order according to the magnitudes of their eigenvalues, and the first L (generally, L < N) eigenvectors are selected as the bases, which are commonly called Eigen faces. These Eigen faces with large Eigen values represent the global, rough structure of the training images, while the Eigen faces with small Eigen values are mainly determined by the local, detailed components. For face recognition, when the testing images have variations caused by local deformation, such as different facial expressions [25], PCA can alleviate this effect. However, when the variations are caused by global components such as lighting or perspective variations, the performance of PCA will be greatly degraded.

C. Kernel PCA

With the Cover's theorem, nonlinearly separable patterns in an input space will become linearly separable with high probability if the input space is transformed nonlinearly into a high-dimensional feature space. We can, therefore, map an input variable into a high-dimensional feature space, and then perform PCA. For a given nonlinear mapping ϕ , the input data space R^N can be mapped into a potentially much higher dimentional feature space F

$$\phi : R^N \longrightarrow F,$$
$$Y \longrightarrow \phi(Y) \quad (13)$$

Performing PCA in the high-dimensional feature space can obtain high-order statistics of the input variables; that is, also the initial motivation of the KPCA. However, it is difficult to directly compute both the covariance matrix and its corresponding eigenvectors and eigen values in the high-dimensional feature space. Fortunately, kernel tricks can be employed to avoid this difficulty, which compute the dot products in the original low-dimensional input space by means of a kernel function [26].

Define a M *M Gram matrix R, where M is the number of training images used, and the elements of R can be determined by virtue of the kernel function.

The orthonormal eigenvectors $\gamma_1, \gamma_2, \gamma_3, \dots\dots\dots\ \gamma_m$ of R corresponding to the m largest positive eigen values.

In Practical face recognition application, three classes of kernel functions have been widely used, which are the polynomial kernels, Gaussian kernels, and sigmoid

ISSN: 2277-3754
ISO 9001:2008 Certified
International Journal of Engineering and Innovative Technology (IJEIT)
Volume 2, Issue 1, July 2012

kernels, [26], here, in this Gaussian kernel is used:

Fig. 8: Eigenmask Used In Method

$$Gaussian\ Kernel: K(Y_i, Y_j) = exp\left(-\|\|Y_i - Y_j\|\|^2 | 2\sigma^2\right) \quad (14)$$

Where d is a positive integer, σ > 0, k > 0, and υ < 0. In [27], the polynomial kernels are extended to include fractional power polynomial (FPP) models, i.e. 0 < d< 1, where a more reliable performance can be achieved.

D. Doubly nonlinear mapping kernel PCA

Although we do not need to perform the mapping explicitly in KPCA, and all the computations are implemented in the input space instead of the high-dimensional feature space, In this section, we will propose a novel KPCA with doubly nonlinear mapping, which considers not only the statistical property of the input Gabor features, but also the spatial information about human faces.

As discussed in the above section- the Gabor feature vector of an input image can be represented by a dimensional vector is a concatenation of the Gabor representations $Y_{\omega,\theta,}$ i.e [$y_{\omega,\theta}(0,0), y_{\omega,\theta}$ (0,1),….. $y_{\omega,\theta}(N_c - 1, N_r - 1)]^T$, which is normalized to have zero mean and unit variance. On the one hand, for each $Y_{\omega,\theta,}$, wwe can group the $N_c * N_r$ output values together to form a histogram, which represents a probability distribution of $Y_{\omega,\theta,}$.e., different values of $Y_{\omega,\theta,}$ have different statistical probabilities. We should note that $Y_{\omega,\theta,}$ does not consider the spatial information, i.e., pixel position (u, v), of the input, but only the magnitude of $Y_{\omega,\theta,}(u,v)$. A normal distribution N (0, 1) is adopted to estimate the probability density function (pdf) p ($Y_{\omega,\theta,}$)in our algorithm. On the other hand, the output is related to the pixel position, which has different spatial importance in a face image. Accordingly, for features y (u, v, ω, θ) € Y.

In other words, each element y (u, v) € Y is treated equally and acts in the same role. However, as discussed above, due to the uneven statistical probability of Y and the different spatial importance of pixel (u, v) in a face image, the elements with different values and spatial locations should be assigned different weights for discrimination. An output feature with a higher probability should provide more discriminate information for recognition, and the elements derived from the important facial features such as eyes, mouth, nose, etc., should also be emphasized. Therefore, a nonlinear mapping Ψ is devised to emphasize those features that have both higher statistical probabilities and spatial importance.

$$\Psi: R^N \to R^N$$
$$Y \xrightarrow{E} \Psi(Y) \quad (15)$$

Where, E is the eigenmask [28], [29] which is used to represent the importance of different facial positions. The eigenmask is a modification of the first eigenface f_c derived from a set of training images.

The statistical probability of y (u, v) is determined by the value of, y and the spatial importance of y(u,v) is determined by the value of the eigenmask at the same pixel position, i.e.,s= E(u , v). In other words, the mapped value z (u, v) is determined by its Gabor representation value and the corresponding eigenmask value . Therefore, we have

$$y(u,v) \to z(u,v) = \Psi(y(u,v))$$
$$= \Psi(y, E(u, v)) \quad (16)$$

Suppose that the statistical property of the Gabor representation and the spatial information about faces are complementary to each other, and y and s are independent of each other. The mapping is, therefore, the product of two nonlinear mapping functions. This has the advantage that $\Psi_1$and Ψ_2 can be designed independently according to their respective properties. For face recognition, the difference between a query input and the faces in a database is computed, and the input is assigned to the one that has the minimal difference.

V. EXPERIMENTAL RESULTS

ISSN: 2277-3754
ISO 9001:2008 Certified
International Journal of Engineering and Innovative Technology (IJEIT)
Volume 2, Issue 1, July 2012

Fig. 9 : Features extraction from fingerprints

Table III: Percentages Match in Inter-Testing

Finger Print To be matched	Finger Print to be matched with	Total Time Taken	Match -ed Perc-entage
1.0000	2.0000	0.0624	30.0000
1.0000	5.0000	0.1716	35.0000
1.0000	8.0000	0.1248	40.0000
1.0000	11.0000	0.1092	40.0000
4.0000	5.0000	0.3744	43.9024
4.0000	8.0000	0.2496	26.8293
4.0000	11.0000	0.2652	24.3902
7.0000	8.0000	0.1872	35.4839
7.0000	11.0000	0.1560	29.0323
10.0000	11.0000	0.2808	25.0000

Table IV: Percentages Match in Intra-Testing Case 1

Finger Print To be matched	Finger Print to be matched with	Total Time Taken	Matched Percentage
1.0000	1.0000	0.0780	100.0000
1.0000	2.0000	0.0312	30.0000
1.0000	3.0000	0.0624	35.0000
1.0000	4.0000	0.0936	40.0000
1.0000	5.0000	0.1560	35.0000
1.0000	6.0000	0.0936	30.0000
1.0000	7.0000	0.0936	35.0000
1.0000	8.0000	0.1092	40.0000
1.0000	9.0000	0.0624	25.0000
1.0000	10.0000	0.1716	40.0000
1.0000	11.0000	0.0936	40.0000
1.0000	12.0000	0.1248	35.0000

Table V: Testing Of Face Features

Case No.	Total faces	No. of pass results	No. of failure	No. of Unconsidered image	Total percentage	Classi_Accuracy
1	8	5	2	1	62.500	--------
2	8	6	1	1	75	**68.7500**
3	8	6	2	0	75	**70.8333**
4	8	5	2	1	75	**68.7500**
5	8	8	0	0	100	**75**
6	8	7	1	0	87.500	**77.0833**
7	8	8	0	0	100	**80.3571**
8	8	8	0	0	100	**82.8125**
9	8	6	2	0	75	**81.9444**
10	8	4	4	0	50	**78.7500**
11	8	8.	0	0	100	**80.6818**
12	8	8	0	0	100	**82.7555**

Table VI : Improved Results by Fusion of Both Face and Finger Prints

Case No.	Total faces	No. of pass results	No. of failures	No. of Unconsidered image	Total percentage	New Classi_Accuracy
1	8	8	0	0	100	**100**
2	8	7	0	1	87.5000	**93.7500**
3	8	7	1	0	87.5000	**91.6667**
4	8	5	2	1	62.5000	**84.3750**
5	8	8	0	0	100	**87.5000**
6	8	8	0	0	100	**89.5833**
7	8	8	0	0	100	**91.0714**
8	8	8	0	0	100	**92.1875**
9	8	8	0	0	100	**93.0556**
10	8	4	4	0	50	**88.7500**
11	8	8	0	0	100	**89.7727**
12	8	8	0	0	100	**90.6250**

VI. CONCLUSION

A multimodal biometric recognition system based on fusion of fingerprint and face, has been Done. Fusion of these two biometric traits is carried out at a matching score. Based on the proximity of the characteristic feature vector, each subsystem has its own matching score. These individual scores are finally fused into a final matching score, which is the input of the decision module. To compare a considerable outperformance and multimodal system with the unimodal systems, a final ROC curve has been plotted and demonstrates that the proposed approach gives robustness. The current work done can be improved along two directions. The first direction is to improve the accuracy by designing more complex matching strategy. The second direction is to change the resources like Fusion of three biometrics ‘Face, Fingerprint and Iris’ can be done. Orientation angles can be increased. Fisher Faces can be used instead of Eigen Faces. And to study how the performance changes while some information is

ISSN: 2277-3754
ISO 9001:2008 Certified
International Journal of Engineering and Innovative Technology (IJEIT)
Volume 2, Issue 1, July 2012

not used, like ridges, orientation angles or frequency images.

ACKNOWLEDGMENT

The authors are grateful to the P.D.M College of engineering. for extending all the facilities and constant encouragement for carrying out this research work.

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ISSN: 2277-3754
ISO 9001:2008 Certified
International Journal of Engineering and Innovative Technology (IJEIT)
Volume 2, Issue 1, July 2012

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