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Feature Level Fusion for Fingerprint using Neural Network for Person Identification

Siddiqui Almas
Research Student
Dr. B.A.M. University, Aurangabad

Lothe Savita A.
Research Student
Dr.B.A.M. University, Aurangabad

TelgadRupali L.
Research Student
Dr. B.A.M. University, Aurangabad

Deshmukh P. D.
MGM's, Dr. G.Y. Pathrikar, College of CS & IT, Aurangabad

ABSTRACT
Security plays a very important role in one's life. Biometrics is an effective technology for personnel identity authentication. It has the capability to reliably distinguish between an authorized people. This paper presents the fusion of fingerprint modalities at Rank level fusion as well as feature level fusion. This paper includes well-known feature extraction method of Gabor Filter in rank level fusion and minutiae feature extraction method for feature level fusion. Decision making approach is used at rank level and Neural Network approach is used for matching at feature level fusion. Multiple instances for one biometric traits are used. The system activate through artificial neural network. The proposed approach for feature level fusion provides the better result. The recognition rate is increased & the error rate is decreased by with the help of this system.

Keywords
Fingerprint, Rank-level fusion, features level fusion, Neural Network.

1. INTRODUCTION
Biometrics is an effective technology for personnel identity authentication. It is a science which deals with verifying the identity of a person using his physical or physiological characteristics [1]. A biometric system is an automatic recognition of an individual based on some sort of unique features or characteristics possessed by the individual. Biometric systems have been developed based on fingerprints, facial features, voice, hand geometry, handwriting, iris and retina etc. Biometrics technology verifies or identified a person based on physical or behavioral characteristics. [2]

In the identification mode, the system recognizes an individual by searching the templates of all the users in the database for a match. Therefore, the system conducts a one-to-many comparison to establish an individual's identity.

A biometric system which relies on presence of much evidence for personal identification is called multimodal biometric system. Multimodal Biometric system uses multiple physical or behavioral characteristics for person's identification. Multimodal Biometric system has better performance than the single Biometric system [3, 4].

A multimodal system can combine any number of independent biometrics and overcome some of the limitations presented by using just one biometric as your verification tool. Multimodal are generally much more essential to fraudulent technologies, because it is more difficult to form multiple biometric characteristics than to form a single biometric characteristic thus provide higher accuracy rate and higher protection from spoofing. Some of the

limitations of a unibiometric system can be addressed by designing a system that consolidates multiple sources of biometric information. This can be accomplished by fusing, for example, multiple traits of an individual, or multiple feature extraction and matching algorithms operating on the same biometric. Such systems, known as multibiometric systems [5, 6], can improve the matching accuracy of a biometric system.

2. MODULES OF MULTIMODAL BIOMETRICS
Multimodal biometric system has four modules:
I. Sensor module,
II. Feature extraction module,
III. Matching module,
IV. Decision making module respectively.

I. **Sensor module:** - At sensor module biometric modalities are captured and these modalities are given as inputs for feature extraction module.

II. **Feature extraction module:** - At feature extraction module features are extracted from different modalities after preprocessing. These features yields a compact representation of these traits or modalities and these extracted features are then further given to the matching module for comparison.

III. **Matching module: -** In matching module extracted features are compared against the templates which are stored in database.

IV. **Decision making module: -** In this module user is either accepted or rejected based on the matching in the matching module. [7]

The block diagram for general multimodal biometric system is as shown in Fig.1.

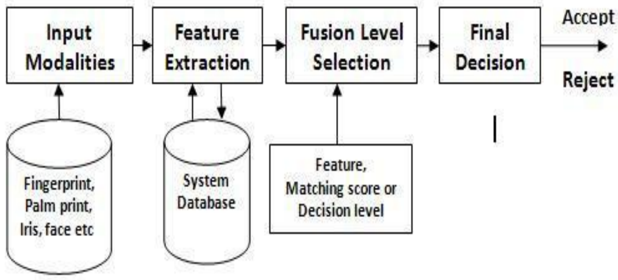


Fig 1: Block Diagram of General Multimodal Biometrics.

Following are some fusion levels in multimodal biometrics:
The three possible levels of fusion are: [7].
(a) Fusion at Sensor level.
(b) Fusion at the feature extraction level,
(c) Fusion at the matching score level,
(d) Fusion at the decision level.

These three levels of fusion are described as follows:

(1) Fusion at the sensor level: Sensor level fusion is the consolidation of evidence presented by multiple sources of raw data before they are subjected to feature extraction. It can benefit multi-sample systems which capture multiple snapshots of the same biometric.

(2) Fusion at the feature extraction level: The data obtained from each sensor is used to compute a feature vector. As the features extracted from one biometric trait are independent of those extracted from the other, it is reasonable to concatenate the two vectors into a single new vector. [8].

(3) Fusion at the matching scores level: Each system provides a matching score indicating the proximity of the feature vector with the template vector. These scores can be combined to declare the reality of the claimed identity.

(4) Fusion at the decision level: Each sensor can capture multiple biometric data and the resulting feature vectors individually classified into the two classes accept or reject.

In a multi biometric system, fusion is carried out at this level when only the decisions output by the individual biometric matchers are available.

Fingerprint recognition refers to the automated method of verifying a match between two human fingerprints.

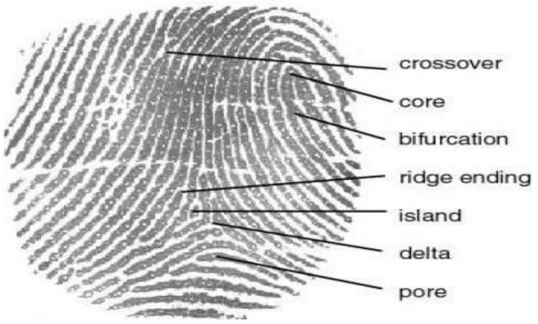


Fig 2: Fingerprint Image

Fingerprint recognition is one of the most well known biometrics, and it is by far the most used biometric solution for authentication on computerized systems. The fingerprint images are classified into five categories: whorl, right loop, left loop, arch, and tented arch. Finger ridge patterns do not change throughout the life of an individual. This property makes fingerprint an excellent biometric identifier. A fingerprint usually appears as a series of dark lines that represent the high, peaking portion of the friction ridge skin, while the valleys between these ridges appears as white space and are low, shallow portion of the friction ridge skin. Fingerprint identification is based primarily on the minutiae, or the location and direction of the ridge endings and bifurcations long a ridge path. Fingerprints are usually considered to be unique, with no two fingers having the exact same dermal ridge characteristics. [7]

3. RELATED WORK

Kisku et al. [4] developed a multimodal biometric system using sensor level fusion scheme for face and palmprint. Rossa and Govidarajan [5] developed a multimodal biometric system for face and hand using feature level fusion with PCA (Principal Component Analysis) and LDA (Linear Discriminant Analysis) method. It improves matching performance at FAR 0.01% and GAR 80%.

Y.Yao et al. [6] developed a multimodal biometric system using face and palmprint at feature level. Here, the Gabor features of face and palmprints are extracted separately. Extracted features are then analyzed using PCA. Finally the feature level fusion is carried out to form a fused feature space.

Gian Luca Marcialis and Fabio Roli [7] developed for multi sensor fingerprint verification system using decision-level fusion of optical and capacitive sensors. When compared with individual sensor (the optical sensor) the proposed multi-sensor system improves performances. Ajay kumar and sumit shekhar [8] developed a biometric system of palmprint recognition using rank level fusion. Snelick et al. [9] proposed a multimodal system for face and fingerprint, with fusion methods at the score level. Maruf Monwar and Marina Gavrilova [10] developed a multimodal biometric system of face, ear and signature using rank level fusion with borda count and logistic regression method. They obtained EER 1.12% when compared with score fusion EER is 1.88%. M. Nageshkumar et al. [11] have proposed multimodal system for face and palmprint using match- score level fusion. The overall accuracy of the proposed system is more than 97%. Nandakumar et al. [12] proposed a minutiae and texture based fingerprint fusion study using a quality-weighted sum (QWS) rule for score level fusion. Rattani et al. [13] proposed a multibiometric system of face and fingerprint using feature level fusion. The proposed system obtained accuracy of 96.66%. Baig et al. [14] developed a multimodal system for fingerprint and iris using score level fusion, which utilizes a single hamming distance matcher.

4. METHODOLOGY

This paper presents the rank level fusion approach and feature level fusion approach for different fingerprint biometric system of a same person. In this paper we have combined the features of same trait using fingerprint. This paper uses the different fingerprint biometrics, feature extraction by using Gabor filtering and minutiae level. For fingerprint recognition system multi-instances approach is used. Then match score is calculated & neural network approach is used for decision making at feature level.

Process of fingerprint recognition system shows the following steps:

1. Fingerprint Image Acquisition:

Performing image acquisition in image processing is always the first step in the workflow sequence because, without an image, no processing is possible. In the first step fingerprint image is taken from the available database.

2. Fingerprint Preprocessing: The preprocessing of fingerprint image is related to the removal of noises detecting edges and scaling [16].

3. Feature Extraction:

The enhanced fingerprint image is binarized and thinned that image which reduces the ridge thickness to one pixel wide. The skeleton image is used to extract minutiae points which are the points of ridge endings and bifurcations.

4. Matching: The matching can be done with the help of Neural Network.

5. Neural Network: Neural Network is a processing units and adaptive connections that are designed to perform a specific processing function. It is purely inspired; that is they are composed of elements that perform in a manner that is similar to the most elementary functions of the biological neuron. These elements are then organized in a way that may be or may not be related to the anatomy of the brain. Neural Network is composed of a number of nodes connected by links. Each link has a numeric weight associated with it. [16]

The complete work has been shown in the following diagram:

5. THE PROPOSED METHOD

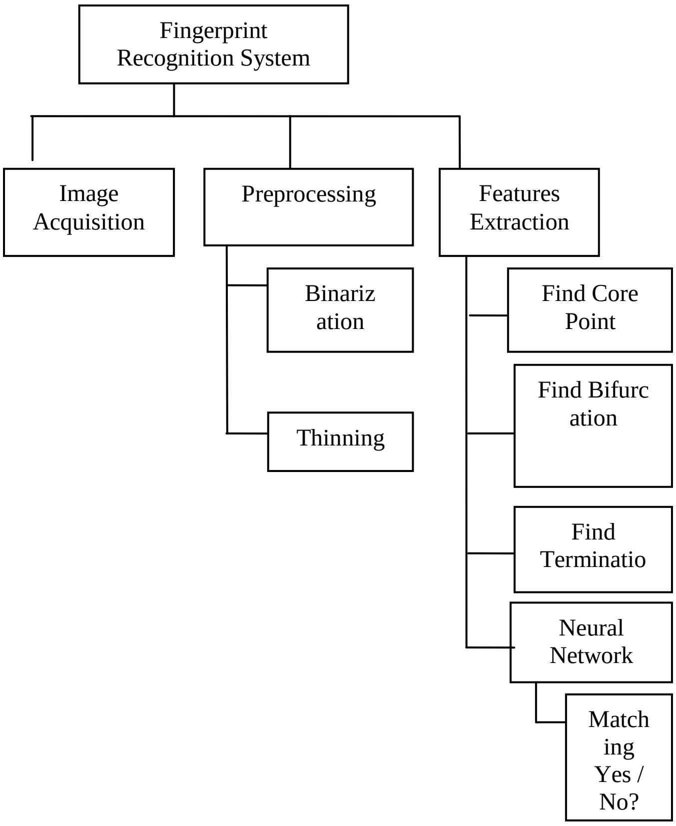


Fig.3: Minutiae Based Fingerprint Recognition process using Neural Network.

6. RANK LEVEL FUSION (METHOD 1):

In this method we have used above given steps and for feature extraction we have use Gabor filter on Fingerprint Sample1 and Sample2. A Gabor filter is a linear filter whose impulse response is a defined by harmonic function multiplied by a Gaussian function. In image processing a Gabor filter, is a linear filter used for edge detection. Gabor filters, simulated visual vertex cells have the properties of spatial localization, orientation selectivity and spatial frequency selectivity. Gabor filter can remove noise and preserve the true ridge and valley structures thus showing good performance [17].The filter based algorithm uses a bank of Gabor filters captures the local and global details in Fingerprint. The matching performance can be improved by combining the decisions of the matchers based on complementary fingerprint information [18].

7. FEATURE LEVEL FUSION (METHOD 2)

The proposed approach is based on minutiae based fingerprint recognition process includes the above given steps:

Features Extraction:

The enhanced fingerprint image is binarized and thinned that image which reduces the ridge thickness to one pixel wide. The skeleton image is used to extract minutiae points which are the points of ridge endings and bifurcations. The location of minutiae points along with the orientation is extracted and stored to form feature set. For extraction of minutiae points eight connected pixels are used [18].

The Crossing Number (CN) method is used to perform minutiae extraction. This 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

$$CN = 0.5\sum_{i=1}^{8} | P_i - P_{i+1} |$$

P9 = P1

where Pi is the pixel value in the neighborhood of P. After the CN for a ridge pixel has been computed, the pixel can then be classified according to its CN value. A ridge pixel with a CN of one corresponds to a ridge ending, and a CN of three corresponds to a bifurcation. For each extracted minutiae point, the following information is recorded:

1. X and Y coordinate,
2. Orientation of the associated ridge segment, and
3. Type of minutiae (ridge ending or bifurcation).

Matching:

There are many fingerprint matching techniques. I have used minutiae based matching.

We perform Neural Network to check whether they belong to the same person or not. Using Neural Network minutiae based fingerprint matching gives accurate matching results. There are many different types of the neural networks such as perceptron, back propagation network, counter propagation network, Hopfield networks [19]. Feed forward backpropogation network is used. It is a collection of processing units and adaptive connections that are designed to perform a specific processing function. Neural networks are very good at pattern-recognition and pattern-matching tasks [20].

Three different kinds of samples are applied on the network to perform different activities:

1. Training: These are presented to the network during training and the network is adjusted according to its error.

2. Validation: It is used to measure network generalization, and to halt training when generalization stops improving.

3. Testing: It is used only for testing the final solution in order to confirm the actual predictive power of the network. In our work we have conducted several training sessions. The training measures the performance on the basis of Mean Squared Error. It is the average squared difference between output and target. Lower values of mean square errors are considered as better one while zero denotes no error.

However, its performance is needed to be evaluated. This is carried out in two ways.

1. Confusion matrix
2. Receiver Operating Characteristic.

1. Confusion matrix:

Confusion matrix is a table layout, which visualizes the performance of an algorithm. The term confusion matrix defines a table which contains the information regarding the actual and anticipated classifications processed by the classification system. The evaluation is done with the help of the data in the matrix. [21]

2. Receiver Operating Characteristic:

Receiver Operating Characteristic (ROC) graphs is employed for organizing the classifiers and visualizing their performance. Here, it is used to compute the accuracy of fingerprint

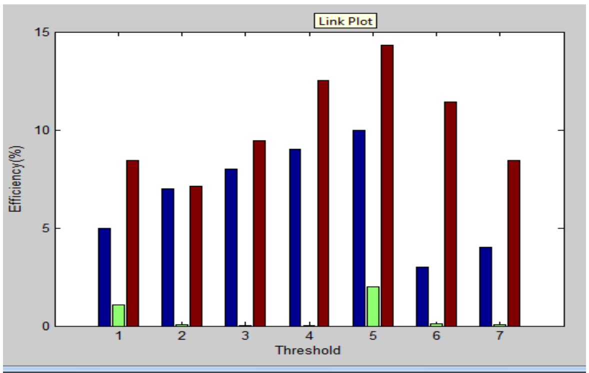
8. EXPERIMENTS AND RESULTS

The proposed fingerprint recognition system is evaluated using three different data bases of fingerprint images i.e. KVKR-Fingerprint database, FVC 2002, FVC 2004 database. The KVKR-Fingerprint database is our own developed database

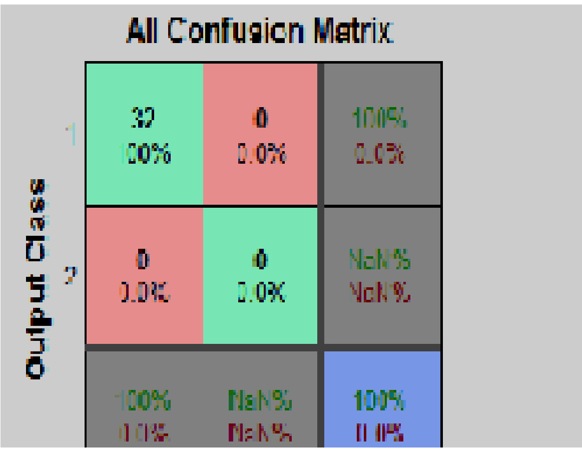
consists of 100x10= 1000 images of 8 bit gray level JPEG images
of left and right hand with different challenging condition. The standard databases namely, Four distinct databases, for FVC 2002 & FVC 2004 as DB1, DB2, DB3 and DB4.
The proposed system has been implemented using MATLAB. The biometrics obtained from 100 persons is used for evaluation. We present a comparison between Borda count method and logistic regression methods are obtained. From the comparison results that rank-level fusion with the logistic regression approach provided the better performance in terms of low error rate and increase the recognition rate of multibiometric systems, because in this approach, weights are assigned to different matchers according to their performance. The performance of the proposed system is evaluated using the parameters such as False Rejection Rate (FRR) and False Acceptance Rate (FAR). The following table shows the Rank level fusion of fingerprint images using Borda count method and Logistic regression method.

Table 1. Results using Threshold Value on Fingerprints

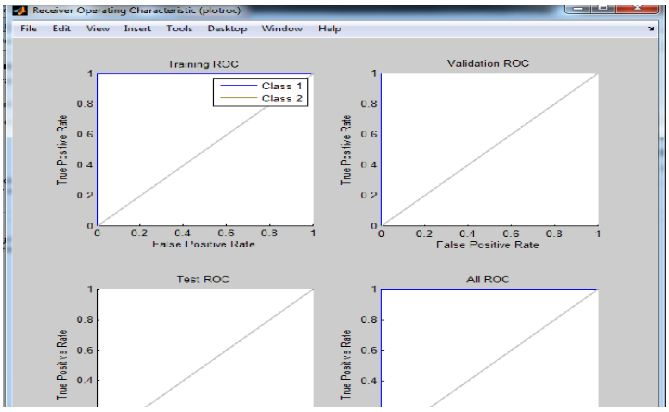
Trait	**Algorithm**	**Accuracy**	**FAR (%)**	**FRR (%)**
Fingerprint (Multibiometrics)	Minutiae extraction and Neural Network	96	1.24	6.09



Graph 1. Efficiency of the fingerprint Identification based on the threshold value.



Graph 2. Confusion matrix



Graph 3. ROC of the fingerprint Identification.

Table 2. Results using Neural Network on Fingerprints

THRESHOLD VALUE	**FALSE ACCEPTANCE RATE (FAR (%))**	**FALSE REJECT RATE (FRR (%))**
5	0.084	8.44
7	0.073	7.12
8	0.024	9.44
9	0.012	12.53
10	0	14.32
3	0.094	11.44
4	0.084	8.44

9. CONCLUSION

This paper developed a Multimodal biometric personal authentication system using a fingerprint. The proposed system uses Borda count method and logistic regression method to integrate the rank of individual matcher. The overall accuracy of the proposed system is more than 97%. The overall matching performance can be improved by combining the decisions of the matchers based on Gabor filter. The ranks of individual matchers are combined using the highest rank, Borda count, and logistic regression approaches. The results indicate that fusion of individual multi biometrics for fingerprint can improve the overall performance of the biometric system, even in the presence of low quality data. From the comparison results that rank level fusion with the feature level fusion approach provided the better performance in terms of error rates at FAR of 0.08% at FRR of 89.2%.
In the future work we can combine one or two traits to increase the recognition rate by using neural network.

10. ACKNOWLEDGEMENT

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12. AUTHOR'S PROFILE

Almas M. N. Siddiqui obtained her M. Phil degree in Computer Science from Y.C.M.O.U., Nashik in 2009. Currently pursuing her Ph. D. degree in Computer Science from Dr. Babasaheb Ambedkar Marathwada University, Aurangabad. Her research interest areas are Biometrics, Image Processing, Neural Network, and Data Mining. She is a life time member of IETE. She has published more than 25 research publications in various National, International Conferences, Proceedings and Journals. Currently she is working as Asst. Professor in Vivekanand College, Aurangabad.

Rupali L. Telgad M.Sc (Comp Sci), M. phil (CS), Ph.D (appeared). Presently working as an Assistant Professor in MGM Dr. G. Y. Pathrikar College of Computer Science and IT, Aurangabad, MS India. She is associated with MGM since 9 years imparting teaching instructions to various undergraduate and post graduate courses in computer science and Information Technology and Computer Application. She has published near about 24 research papers in national and international conference and journals. She is Life member of ISCA. Her research interests are Biometrics, and Advanced Image Processing.

Dr. Prapti D. Deshmukh-Patil, M. Sc Physics (Elect), M. Sc (Comp Sci), Ph.D. presently working as a Principal in MGM Dr. G. Y. Pathrikar College of Computer Science and IT, Aurangabad, MS-India. She is associated with MGM since 16 years imparting teaching instructions to various undergraduate and post graduate courses in computer science and Information Technology. She has published several research papers in national and international conference and journals. Seven students are doing their Ph. D in Computer Science in various areas of multibiometric and biomedical image processing under her guidance. She is a Fellow of IETE, Life member of CSI, Life member of ISCA. Her research interests are Biometrics, Advanced Pattern Recognition, Neural Network, and Advanced Image Processing. She is recipient of best poster presentation award at ISCA 2013 and Amazing idea award in IEEE Science and information conference, London, UK. She is reviewer and editor of several journals.