Biometric Identification System using Fingerprint and Knuckle as Multimodality Features

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***Abstract*—Advancement of information technology coupled with the need for high security for passwords, the application of biometric as identification and recognition process serves a crucial purpose to avoid the risk to find or still. The texture pattern produces by hand geometry for authenticated access control it is the true substitute for passwords and identifiers in converse with the existing method biometric traits i.e. fingerprint and knuckle multimodal authentication system utilize line texture pattern to achieve actual personal identification. In this paper, we proposed the authentication system which uses multimodality feature extraction techniques with neural network as a classifier. Knuckle is a quite unique biometric trait having inherent skin pattern combined with fingerprint to implement multimodality. The performance of the system has been tested on biometric database that includes 16 subject's hands. The experimental result shows that multimodality features based authentication system has better authentication rate over single feature.**

Keywords—Fingerprint, knuckle, neural network, authentication, feature extraction

I. INTRODUCTION

Now a days, it is more important to identify the spoof person or unknown criminals at any crime, therefore it is crucial to utilize the latest human identification techniques [1]. Part of a human hand having many unique features such as top knuckles, middle knuckle, base knuckles, hand vein shape, nail shape, fingerprints. Knuckle and fingerprints are considered as unique features for the identification purpose, hence in this research work biometric traits are being used. A fingerprint is a graphical pattern of ridges and valleys on the surface of a human finger. Due to the uniqueness and permanence of fingerprints, among different biometric fingerprint identification is widely accepted and commonly used method for person's verification and validation [2]. Directional behavior is an obvious characteristic in a fingerprint image caused by the continuous flow of fingerprint ridges whose orientations are slowly changing in the fingerprint pattern [3]. Finger consists of different global and local features for matching purposes. Global features include Basic Ridge Pattern Area, Delta, Type Lines, and Ridge Count etc. and local features include minutiae points. These points show immutable and distinct characteristic fingerprint image. The finger-back surface, also known as dorsum of hand, can be highly useful in user identification and has not yet attracted the attention of researchers [4]. The contact free imaging of the finger back surface is highly convenient to users. The outer surfaces of finger joint is the new member of biometrics family which have even more obvious line features as opposed to the other hand geometry biometrics, in spite of very tiny comparable area. The skin pattern on the finger-knuckle is highly rich in texture due to skin folds and creases, and hence, can be considered as a biometric identifier. Further, advantages of using Finger Knuckle Print (FKP) include rich in texture features, easily accessible, contact-less image acquisition, invariant to emotions and other behavioural aspects such as tiredness, stable features and acceptability in the society [4]. Fingerprints have long been used in the identification of individuals because of the well-known fact that each person has a unique fingerprint [5]. Finger Knuckle prints are one of the recent recognition system, as everyone on Earth appears to have a unique set of finger knuckle prints at any given time. The performance of an automatic identification system relies heavily on the modalities image quality which can be affected by several factors such as the presence of scars, variations of the pressure between the finger and acquisition sensor, worn artefacts, and the environmental conditions during the acquisition process. Hence, the existing finger print technology does not provide much accuracy thus resulting into implementation of fusion techniques in the existing technology.

These unimodal biometric systems are faced with a variety of problems, noise in sensed data, non-universality, inter-class similarities, and spoof attacks [6]. Multi-biometrics is a relatively new approach to overcome these problems. Besides enhancing matching accuracy, the multi-biometric systems have many advantages over traditional uni-biometric systems. They address the issue of non-universality. It becomes increasingly difficult for an impostor to spoof multiple biometric traits of an individual. A multi-biometric system may also be viewed as a fault tolerant system. A multi-biometric system relies on the evidence presented by multiple

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sources of biometric information based on the nature of these sources.

In this research, we proposed fusion system of two biometrics at the feature level based on artificial neural network as a classifier. The system fused at feature level can improve the recognition rate, reduce the number of features, reduce the total equal error rates and finally decrease the time consumed in recognition to the half [7].

Section 2 of this paper present the proposed authentication system. Section 3 describe the database used and creation of training and testing data. Section 4 present the feature extraction techniques followed by section 5 which describe the neural network as a classifier. Section 6 present the experimental result and finally we conclude in section 7.

II. PROPOSED AUTHENTICATION SYSTEM

In this section we describe the proposed authentication system. It is divided into two phases: i) Registration and ii) Verification phase.

A. Registration Phase

New users are added in the system through one time registration. Figure 1 shows the block diagram for registration phase. In this phase, 7 fingerprint and 7 knuckle images are acquired for the single user using respective acquisition devices. The acquired images are normalized and followed by feature extraction. The extracted features of fingerprint and knuckle are fussed to generate the single fussed feature template. The fussed template is used to train the neural network and make it ready for verification phase.

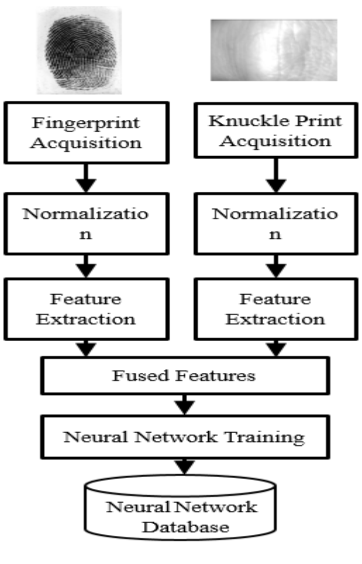

Fig. 1. Block diagram for Registration Phase

B. Verification Phase

Verification phase is used to check the authorized users using the authentication system. Once the user is registered in the system, verification phase can be used on day to day basis. Figure 2 show the block diagram of verification phase. At the time of verification, user fingerprint and knuckle image are acquired using acquisition devices. The acquired images are normalized and individual features are obtain. The feature are fussed and given as an input to train neural network for recognition. The authorized users are authenticated with the access to the premises.

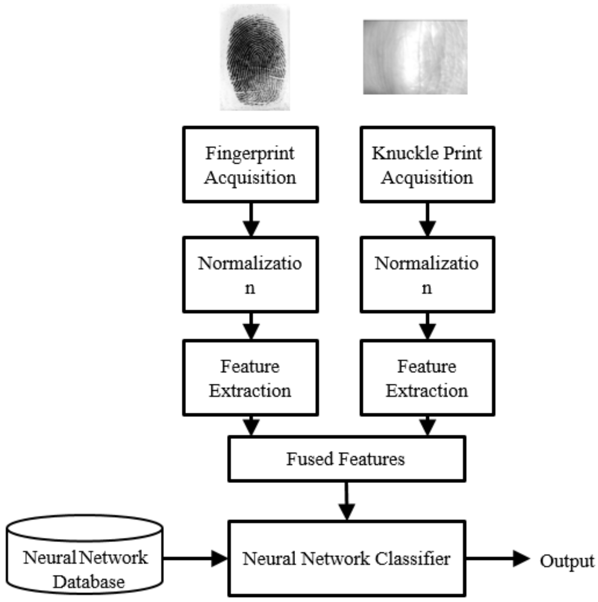

Fig. 2. Block diagram for Verification Phase

III. DATABASE

In the current research work, we used the PolyU FPK Database[11].

A.Data Acquisition

The data of 16 users are created from both male and female with their ages varying from 20 to 60 years with 16 classes. The readymade database for knuckle and finger print is selected from the Hong-Kong university database [reference to database]. Database is collected in two phase with average interval of 7days. In the 1st phase, the 14 samples of the left index finger and 14 sample of knuckle for 7 users were collected. In the 2nd phase, the 14 samples of the left index finger and 14 sample of knuckle for 9 users were collected. The Sensor used for acquiring samples was ‘Optical Sensor’.

B. Creating Training and Testing Data

The collected data is divided into two groups: training images and testing images. In this step, we divide 14 data sample of fingerprint into 7 training samples and 7 testing for each user. Similarly, we do it for knuckle data in respective order of user. For each user, cross-mapping is done to get 49 data sample of training data and 49 data sample of testing data. The figure 3 shows the 49 data sample combination obtain for one user using 7 fingerprint and 7 knuckle images.

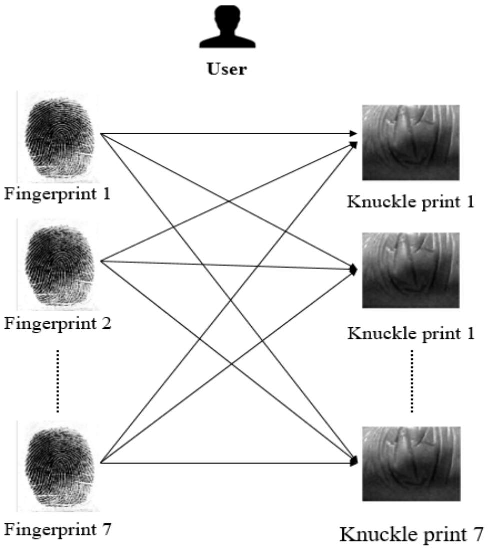

Figure 3. Creation of Training and Testing data

IV. MULTIMODALITY FEATURE EXTRACTION

A. Normalization

Figure 4 show the steps followed to normalized the acquired image. Normalization is very important steps before feature extraction. In this step we improve the quality of image and bring it in template to extract the features. The acquired image is converted to grey scales and resized to 255x255 pixels. The resized image is enhance to improve the contrast and brightness properties of image. Histogram equalization is followed by gabor filter to eliminate the noise from the image.

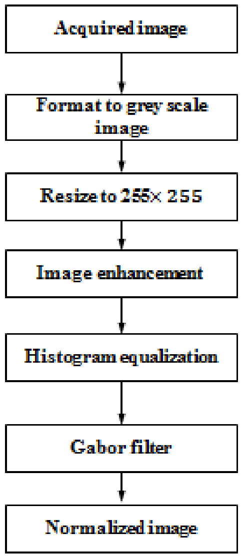

Fig. 4. Normalization of acquired image

B. Feature Extraction

Figure 5 shows the feature extraction steps from fingerprint and knuckle to obtain the fused feature template. The Normalized image is taken as an input as segmented to obtain the ROI.

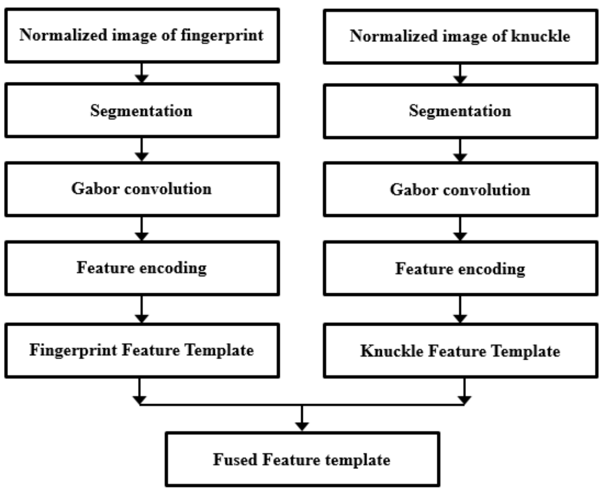

Fig. 5. Feature extraction for fingerprint and knuckle

Figure 6 show the obtained ROI image for fingerprint and knuckle. The ROI is gabor convoluted and further encoded to get the fingerprint feature template and knuckle feature template as show in Figure 7 of size 20x20. Finally, fingerprint and knuckle features are fused to obtain 20x40 size fused feature template.

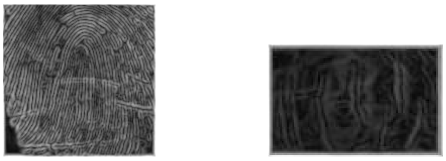

Fig. 6. i) ROI for Fingerprint and ii) ROI for Knuckle

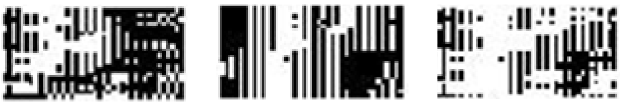

Fig. 7. i) Feature template for fingerprint ii) Feature template for knuckle and iii) Fused feature template

V. MULTIMODALITY FEATURE CLASSIFIER

A proposed scheme for multimodal biometric knuckle print and fingerprint recognition using the neural network is parallel the multimodal biometric takes the individual scores of two traits i.e. knuckle and fingerprint that generate a fused template for training will produce a good accurate result with high efficiency. Current work deals with an efficient knuckle and fingerprint recognition algorithm combining feature based fusion approach for parallel execution. The main purpose of the proposed system is to reduce the error rate as low as possible and improve the performance of the system by achieving good, acceptable recognition and classification rate during identification and authentication.

In the proposed work, the neural network is used for classification and recognition of users. The complete process is divided into two steps: i) Training and ii) Recognition. Recognition is the process to identify the authorized user. Recognition phase is used on a daily basis whereas training is done once or on the addition of new user. In recognition step, single user fingerprint and knuckle are collected and processed to the column vector (as mentioned in feature level fusion). Column vector will be given as an input to the train neural network for recognition. Draw the neural network diagram with input nodes, hidden layer and output nodes.

A. *Training Data*

In our current work, we got 49 combinations of data (7 fingerprint X 7 knuckle images = 49 data sample) for each user. We experimented it on 16 users, so we get total 784 data sample (16 x 49). For every user, each combination of the fingerprint image and knuckle image is pre-processed to get a normalized image. The normalized image is given as in input for feature extraction. We get two feature template, one for fingerprint and other for the knuckle. Each feature template is of size 20x20 matrix. The obtained feature templates are fused to get the final fussed template of size 20x40 matrix. The final fused template is reshaped to column vector (800x1 size). This process is repeated for 784 data sample to get 784 column vectors. Finally, we combine 784 column vectors to create the train data matrix of size 800x784 matrixes. Along with train data matrix, target matrix is created. Target matrix is required to specify which train data belongs to which user. The size of this target matrix will be 16x784. In the target matrix, for first row, 1st to 49th values will be all '1' and rest all will be '0'. Similarly, for the second row 50th-98th value will be '1' and rest all will be zero and so on.

B. *Training Neural Network*

In the current work, we have proposed the experimentation based on two kind of neural network: i) Back-propagation NN and ii) Feed Forward NN. The experiments uses various training pattern: i) trainlm ii) trainbr iii) trainrp and iv) traingdx with two error propagation techniques i.e. MSE and SSE. In the current research we have trained i) fingerprint features, ii) knuckle features and iii) fingerprint & knuckle features. We created a neural network with 800 input nodes, 16 output nodes and 1 hidden layer. Iterate the data matrix and target matrix from 1 to 784. This column matrix are given as an input to the neural network for training. Once all the data is given as an input, the neural network is ready for recognition process.

VI. EXPERIMENTAL RESULTS

We conducted our experiments on backpropagation neural network as a classifier with multimodality features. The entire system is being implemented in MATLAB. The backpropagation neural was created and trained for different values of hidden neural as shown in Table 1. As each value of hidden neuron, Classification and Recognition rate was obtained. The experiment was conducted on a computer with i5 processor with 16 GB of RAM.

TABLE I. CLASSIFICATION AND RECOGNITION RATE ACROSS VARIOUS VALUES OF HIDDEN NEURONS.

Sr. No.	Hidden nodes	Classification	Recognition
1	1	6.25	6.25
2	2	6.25	6.25
3	3	19.13265306	16.96428571
4	4	6.25	6.25
5	5	12.5	12.5
6	6	13.26530612	9.821428571
7	7	100	81.12244898
8	8	9.183673469	9.183673469
9	9	6.25	6.25
10	10	18.23979592	12.88265306
11	15	16.96428571	11.8622449
12	20	100	79.71938776
13	25	15.43367347	12.24489796
14	30	9.948979592	9.693877551

The Figure 8 shows the graphs representing the highest classification rate i.e. 100% is obtained at hidden 7 and 20. Further 81.12% of recognition rate is obtained at hidden neuron 7 and 79.71% of recognition rate is obtained at hidden neuron at 20.

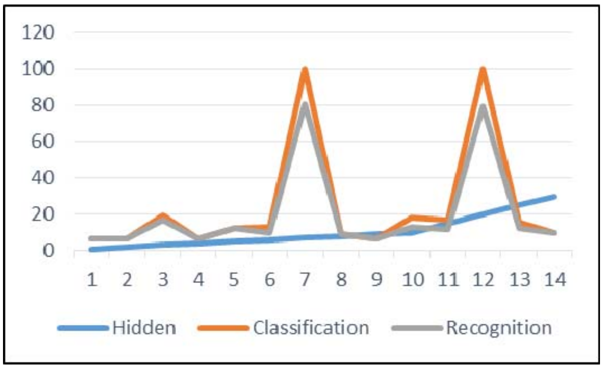

Fig. 8. Graph representing Classification and Recognition Rate across various values of hidden neurons.

Figure 9 show the confusion matrix for recognition rate at hidden neuron 7. Confusion matrix show the recognition percentage within same class and misrecognition percentage in with classes.

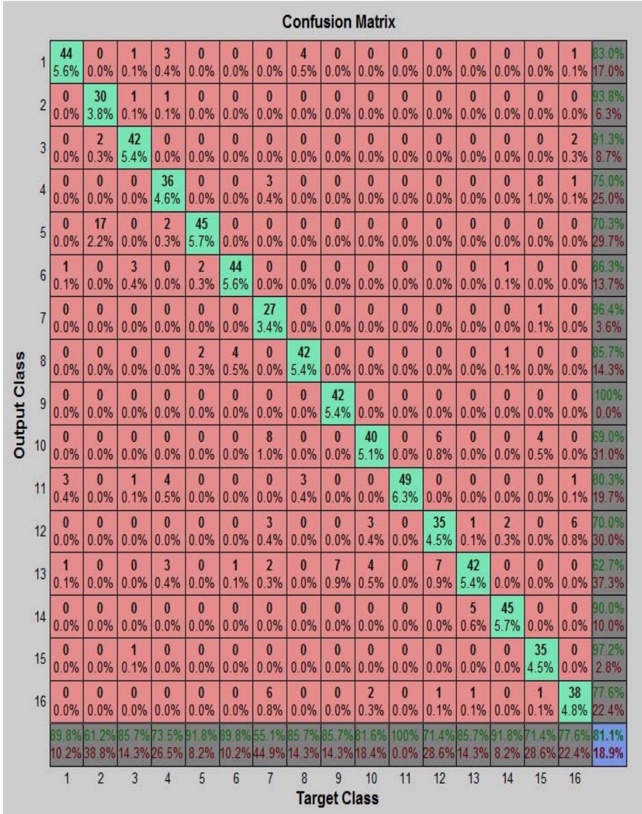

Fig. 9. Confusion matrix for hidden neuron 7.

VII. CONCLUSION

In this research work, we presented biometric authentication system using multimodality features based technique. To authenticate valid user, two different kind of features (fingerprint and knuckle) were extracted from a single user. The two features were fused to get a final feature template and backpropagation neural network is trained as a classifier. The experimental results show that multimodality feature based recognition techniques produce good recognition results with 100% classification and 81.12% recognition rate with neural network with 7 hidden nodes. The performance of the system has been tested on biometric database that includes 16 subject's hands.

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