A Novel Technique to Improve Template Security for Biometric Recognition

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Abstract: *This paper presents one of the new fusion methods for multimodal biometric recognition to improve biometric template security. In this methodology, the process involves embedding finger vein into the hand vein image. Here the necessary features are extracted from the preprocessed images and subsequently, we embed the binary finger vein into hand vein by the use of embedded fusion. Finally the matching score is found out with the help of neural network. The proposed technique is tested on the standard data bases of finger vein and hand vein. This method provides lower false acceptance rate and false rejection rate when compared with other techniques, indicating the effectiveness of the proposed system.*

Keywords: *Template security,* finger *vein, hand vein, embedded fusion, multimodal biometric recognition.*

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1. Introduction

Biometrics offers several advantages over the traditional security measures including non-repudiation, accuracy, screening and security. Today, biometric recognition is a common and reliable way to authenticate the identity of a person through physical measurements of unique human characteristics or behavior. A physiological characteristic is a relatively stable physical characteristic, such as fingerprint, iris pattern, facial feature, hand silhouette and more [10]. Biometric technology offers the promise of an easy and secure method to make highly accurate verifications of individuals. It guarantees a means of identification that cannot be stolen, lost or forgotten, are being increasingly demanded in security environments and applications like access control and electronic transactions [13, 16]. Substitute representations of identity such as passwords and ID cards can be effortlessly mislaid, shared or stolen. Passwords can also be simply guessed using social engineering and dictionary attacks [2, 11] and gives very little security. Since biometric systems need the user to be in attendance at the time of authentication, it can also daunt users from making false denial claims [12].

Performance of a biometric system is measured by their identifying power, which is calculated using the false rejection and false acceptance rates. Multibiometrics provides more security by having multiple samples of a single biometric trait or samples of multiple biometric traits [7, 18]. Multibiometric systems can lessen many of the limitations of unibiometric systems since the various biometric sources normally reimburse for the innate limitations of the other sources [1, 19, 20]. Joining the data obtained from dissimilar sources using an efficient fusion method can considerably increase the overall accuracy of the biometric system and make the system more defiant to spoof attacks as it is difficult to concurrently spoof multiple biometric sources. The aim of multibiometrics is to improve the quality of recognition over an individual method by combining the results of multiple features, sensors, or algorithms. In multi-modal biometrics, choosing of right modality is a challenging task in recognition of a person. In our proposed system, we make use of hand vein and finger vein. In many medical practices, X-ray and ultrasonic scanning are used to form vascular images. This is not acceptable for general purpose biometric applications in the real-world. Therefore, obtaining the vein pattern images in a fast and non-invasive manner is the key challenge in a vein pattern biometric system [4, 8, 22]. The personal identification using hand vein and finger vein has gained more and more research attentions in these years as it seems a better biometric trait than those finger prints and other modalities [9, 24, 26]. The key to multimodal biometrics is the fusion of the various biometric features. Features extracted from the biometric images should be stored securely and for this purpose, embedded fusion is carried out in this paper. In this proposed technique the hand vein and finger vein images are preprocessed and vein features are extracted by using Kirsch’s templates [27]. After extracting the vein features, we embed the binary finger vein into hand vein by the use of embedded fusion. In the recognition stage, the hand veins are extracted from the embedded form and matching score is found out with the help of neural network.

The rest of the paper is organized as follows: The proposed embedded fusion for finger and hand vein-based multimodal biometric recognition technique is presented in section 2. The detailed experimental results and discussion are given in section 3 and the conclusion is summed up in section 4.

2. The Proposed System

Template security is very important for multi-modal biometric recognition. Storing of features extracted from the biometric images should be very secure because if these features are hacked by the attackers, they can easily do malpractice in matching process. The proposed technique is aimed at improving the template security by the use of embedded fusion where the extracted finger vein is fused into hand vein image.

The advantage of embedded fusion is that it improves the template security as the finger vein is fused to the hand vein image without the knowledge of the intruder. The over all flow diagram of proposed system is depicted in Figure1.

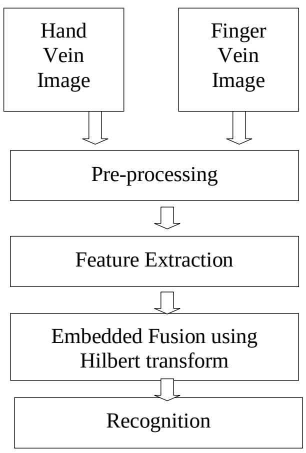

Figure 1. The flow diagram of proposed system.

2.1. Feature Extraction

The hand vein and finger vein images are preprocessed initially so as to make the images appropriate for further processing and also to reduce the noise. From the pre-processed hand vein and finger vein images, the necessary vein features are extracted by using Kirsch's templates. Kirsch's templates are directional filter coefficients and involve spatial filtering of the image using the templates in eight different orientations. Spatial filtering is an image operation where each pixel value is changed by a function of the intensities of pixels in a neighborhood. The Kirsch kernels are non-linear edge detector that finds the maximum edge strength in a few predetermined directions. The operator takes a single kernel mask and rotates it in 45 degree increments through all 8 compass directions: N, NW, W, SW, S, SE, E, and NE (represented by 0, 45, 90, 135,180, 225, 270, and 315 degrees). The edge magnitude of the Kirsch operator is calculated as the maximum magnitude across all directions. The matrix contains the information of a pixel and its neighbours. The edge magnitude of the Kirsch operator is calculated as the maximum magnitude across all directions using the following Equation 1:

$$z_{n,.m} = \max_{h=1,\ldots,8} \sum_{i=-1}^{1}\sum_{j=-1}^{1} y_{ij}^{(h)} \cdot f_{n+i,m+j} \quad (1)$$

Where, h computes the compass direction kernels.

$$y^{(1)} = \begin{bmatrix} 5 & 5 & 5 \\ -3 & 0 & -3 \\ -3 & -3 & -3 \end{bmatrix}; y^{(2)} = \begin{bmatrix} 5 & 5 & -3 \\ 5 & 0 & -3 \\ -3 & -3 & -3 \end{bmatrix}; y^{(3)} = \begin{bmatrix} 5 & -3 & -3 \\ 5 & 0 & -3 \\ 5 & -3 & -3 \end{bmatrix}$$

And so on for $y^{(h)}$ *for* $1 \leq h \leq 8$.

The edge direction is defined by the mask that produces the maximum edge magnitude. The highest output of these filters is taken to form the veins and is extracted. The extraction is carried out with the help of a threshold value set. When the intensity of the processed image is greater than the minimum threshold set, it is classified as the vein pixel. That is if the minimum threshold set be Th_{min}, then if the pixel value pix_i is greater, then it is classified as vein pixel.

This can be represented as:

If ($pix_i > Th_{min}$,), *THEN*
pix_i *is extracted as vein pixel*

The obtained gray scale image is then sharpened using laplacian filter. Subsequently, the finger vein is converted into binary by thresholding such that 90 percent of the image is black and only 10 percent brightest region is white.

2.2. Embedded Fusion

In this process, the binary finger vein is embedded into hand vein by use of embedded fusion technique. The embedding is carried out such that finger vein is placed to vacant spaces in the hand vein so that the images are not distorted. The flow diagram of the embedded fusion technique is given in Figure 2. Here, initially Hilbert transform of the hand vein is taken. Hilbert transform is a linear operator which takes a function, $v[n]$ and produces a function, $H(v[n])$ with the same domain. For a discrete function $v[n]$ with Discrete-Time Fourier Transform (DTFT), F(ω), the hilbert transform is as depicted in Equation 2.

$$H(v[n]) = DTFT^{-1}\{F(\omega).\sigma_H(\omega)\} \quad (2)$$

Where,

$$\sigma_H(\omega) = \begin{cases} e^{\frac{i\pi}{2}}, -\pi < \omega < 0 \\ e^{-\frac{i\pi}{2}}, 0 < \omega < \pi \\ 0, \ \omega = -\pi, 0, \pi \end{cases}$$

By terms of convolution, the above equation can be written as in Equation 3.

$$H(v)[n] = v[n] * h[n] \tag{3}$$

Where,

$$h[n] = DTFT^{-1}\{\sigma_H(\omega)\} = \begin{cases} 0, \; for\ n\ even \\ \dfrac{2}{\pi n}, \; for\ n\ odd \end{cases}$$

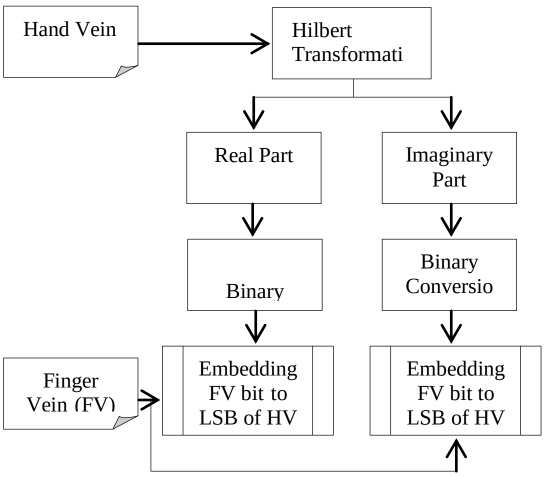

Figure 2. The flow diagram of the embedded fusion technique.

After Hilbert transformation of the hand vein, we obtain the image which has both real and imaginary parts. Then the binary finger vein image is embedded by use of Least Significant Bit (LSB) method to the hand vein so as to improve the security for biometric templates.

2.3. Recognition

In the recognition stage, the hand veins are extracted from the embedded form and matching score is found out with the help of neural network. Initially, from the embedded image, inverse hilbert transform is applied to extract hand veins directly from the embedded image. After extracting the hand veins the rest of the pixels (other than the hand vein pixels) in the embedded image are taken into consideration and LSB bits from those are taken to extract the finger vein image. Subsequently, the images are compared to find out distances which are given used for the training and testing of the neural network which provides the matching score. Here Feed Forward Neural Network (FFNN) with four layers consisting of twenty neurons in the input layer, ten neurons in the first hidden layer, five neurons in the second hidden layer and two neurons in the output layer is used. The FFNN is trained using scaled conjugate gradient algorithm. Distance measures D_1 and D_2 are computed using Euclidean distance metric which is given as input to the neural network. Here, D_1 is the distance between the test hand vein image and the hand vein image in the database. Similarly, D_2 is the distance between the test finger vein image and the finger vein image in the data base. The calculated D_1 and D_2 for all images are used for training the neural network. Here, the input of the neural network is the computed D_1 and D_2. In the training phase, the network is trained under large dataset and in testing phase, the matching score is generated as the output.

3. Results and Discussion

The experimental results of the proposed method for multi-modal biometric recognition are discussed here. The evaluation metrics employed here are accuracy, False Acceptance Rate (FAR) and False Rejection Rate (FRR). The database utilized for our experimentation is taken from the standard data bases [3, 6] for hand vein and finger vein images. The

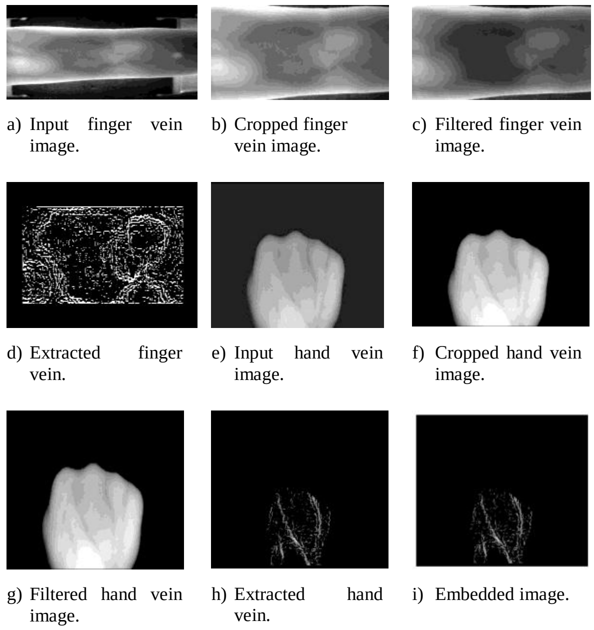

Figure 3. Images at various stages

experimental results at various stages of hand vein and finger vein images are given in the Figure 3.

The performance analysis is made with the use of evaluation metrics of FAR, FRR and accuracy.

The proposed technique is compared with other techniques such as fuzzy score level fusion technique, fuzzy firefly technique and fuzzy genetic technique. Figures 4, 5, 6 and 7 gives the plot of FAR, FRR, FAR-FRR and accuracy graphs respectively.

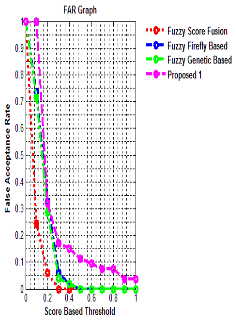

Figure 4. Plot of FAR

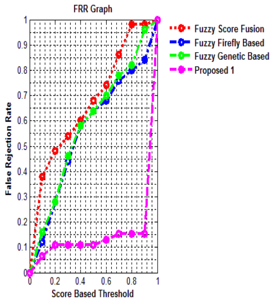

Figure 5. Plot of FRR

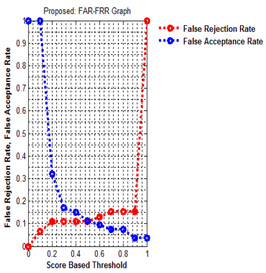

Figure 6. Plot of FAR-FRR.

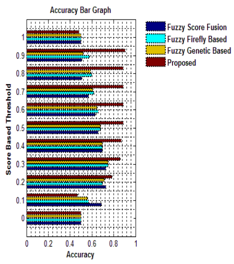

Figure 7. Plot of accuracy.

The graphs are plotted by varying score based threshold in the range of zero to one. By analyzing FAR and FRR curves, we can see that FAR decreases with increase in score threshold and FRR increases with increase in score threshold. FRR-FAR curve obtained is shown in Figure 6 and the lines meet at score threshold of 0.5 when FRR-FAR values were at 0.1 and this indicates improved performance of the proposed system.

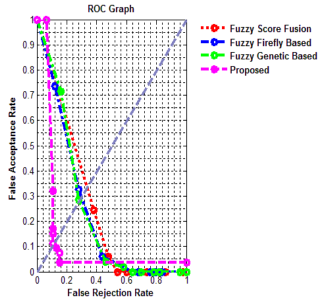

Figure 8. Plot of ROC

Here, the comparative analysis is made by comparing our proposed technique with fuzzy score fusion technique, fuzzy firefly technique and fuzzy genetic technique. The accuracy graph Figure 7 is plotted by varying score based threshold in the range of zero to one by a value of 0.1. For each threshold value set, we can see that our proposed technique has achieved higher accuracy. Highest accuracy of about 90% was obtained when threshold was set at 0.9. From the ROC curves Figure 8, we can see that our proposed technique has achieved lower equal error rate indicating the effectiveness of the proposed technique.

Figure 9 shows the validation performance of the proposed system. The performance is evaluated using Mean Squared Error (MSE) taken for 256 epochs varying from 0 to 255. The best validation performance is achieved is 0.01875 (MSE value) at epoch 106.

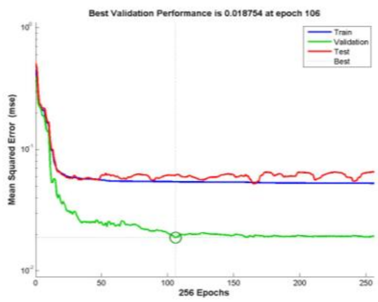

Figure 9. Validation performance.

3.1. Comparative Analysis

The detailed comparative analysis of the related work on hand vein authentication is given in Table 1. All the results presented in this table are in terms of Equal Error Rate (EER), FAR and FRR. EER is defined as a point at which FAR is equal to FRR. Lower the values of EER, better the performance of the system but it varies according to the imaging techniques and number of users in the data base.

4. Conclusions

The main significance of the proposed method is to improve the template security for multi-modal biometric recognition. Storing of feature extracted from the biometric images should be very secure because if these features are hacked by the attackers, they can easily do malpractice in matching process. In this proposed method the finger vein is completely embedded into hand vein so that it could not be intruded. The proposed system is evaluated using parameters of accuracy, FAR and FRR. The experimental results shows that the improved performance of the system when compared with other techniques, indicating the effectiveness of the proposed technique. The technique also achieved highest accuracy of 90% and best validation performance of 0.01875 (MSE value) at epoch 106.

Table 1. Comparative analysis of related work on vein based authentication.

Author	Biometric features	Methodology	Imaging	Database	Performance
Ding,Y., Zhuang, D., and Wang, K [5]	Hand vein	Distance between feature points	Near IR imaging	48 users	FAR = 0 FRR = 0.9
Raghavendra, R., Imran, M., Rao, A., and Kumar, G.H [17]	Hand vein and palm print	Log Gabor transform	Near IR imaging	50 users	FAR = 7.4 FRR = 4.8
		Non standard mask			FAR = 2.8 FRR = 1.4
Lin, C.L., and Fan, K.C [15]	Palm-dorsa vein	Multi resolution analysis and combination	Thermal imaging	32 users	FAR = 1.5 FRR = 3.5 EER = 3.75
Wang, L., and Leedham, G [21]	Hand vein	Line segment Hausdorff distance matching	Thermal imaging	12 users	FAR = 0 FRR = 0
Kumar, A., and Prathyusha, K.V [14]	Hand vein and knuckle shape	Matching vein triangulation and shape features	Near IR imaging	100 users	FAR = 1.14 FRR = 1.14
Wu, X., Gao, E., Tang,Y., and Wang, K [23]	Multiple vein images of hand	SVM classifier	Near IR imaging	96 users	EER = 2.2
Yuksel, A., and Akarun, L [25]	Hand vein	ICA 1, ICA2, LEM and NMF	Near IR imaging	100 users	EER =5.4, 7.24,7.64 and 9.17
Proposed method	Hand vein and finger vein	Sum rule, fuzzy, neural network	Near IR imaging	100 users	EER = 0.16, 0.13,0.1

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