Multi-biometric System for Security Institutions using Wavelet Decomposition and Neural Network

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ABSTRACT
Biometric systems are currently considered one of the leading methods for security and access control systems. The use of multi-biometric in verification and identification provides more reliability and accuracy for such systems. In this paper three biometric traits have been used face, iris and fingerprint for identification purpose. After preprocessing feature extraction for each trait, wavelet decomposition was used. Back-propagation neural network was employed for the training of the system. The results showed a highly accurate recognition rate after 298 epoch of training. A measurement of MSE and PSNR. With false acceptance rate (FAR) of 0% and false rejection rate (FRR) of 3% were calculated for system performance evaluation.

Keywords
Multi-biometric, Feature Extraction, Feature Level Fusion, Wavelet Decomposition, Artificial Neural Network

1. INTRODUCTION
The term biometric, which means “life measurements” in Latin, is a recognition science that identifies individuals based on their physical or behavioral feature, such as fingerprint, iris, DNA. The use of biometric systems has increased in the past years in different security related areas like information security, building access control and boarder passing. A huge effort is dedicated towards the improvement and introduction of a new and more advanced biometric based security systems. These systems have the advantage over other security systems in being easy to use and not like password depended system where the password can be forgotten or card depending systems in which the card can be lost. Biometric system use unique human traits such as physical like fingerprint, iris or face, behavioral like gait or voice or biological like DNA [1].

Unimodal systems use single trait for recognition, the performance of such systems can be affected by noisy data or non-universality [2]. V.Ramya et al [3] proposed a face recognition model that used local face features like mouth end points and eyeballs as an input for neural network. The system achieved 95.00% accuracy. A. Cenys et al [4] presented a model that uses genetic algorithm for palm recognition. Several measures of a palm of a person are made on 25 palm print, this method had a 92-96% reliability. Raid R. Al-Nima [5] presented human ear based authentication system. Information at the feature extraction and at the confidence level, where the matching. Probabilistic neural network was used for pattern recognition. The system achieved (FRR) = 9% and (FAR) = 9%.

On the other hand, the use of multiple traits for the same person provide more accuracy and the short comings of any single trait can be overtaken be the other. Several systems were proposed in this field that used multibiometrics with artificial neural network or other intelligent techniques. Feature level fusion wan performed by Waheeda A. et al [6] with the use of BPSO algorithm to reduce the number of features while keeping the same level of performance. A novel approach was presented by Laheeb M. et al. [7] to authenticate individuals using serial multibiometric mode using palm print, dental and DNA features, features were extraction using KL transform. Verification mechanisms was proposed in PSO and BP neural network-based method, to verify the system were (FAR=2%), (FRR=5%) and (RR=93%). There are a number of fusion scenarios for multibiometric systems like the use of multiple sensors to capture the same trait, the use of multiple samples of the same trait or the system can use multiple feature extraction methods for the same trait or multiple matching methods (algorithms) for the same traits.

2. THE PROPOSED MODEL
In this paper, face, iris and fingerprint were used for identity verification. The system was trained for (10) subjects where a different preprocessing methods were performed depending on the trait, feature vectors were extracted and fused into a single vector. Feature level fusion is considered a powerful type of fusion. Since, all the information of the traits are used for recognition. The fused vectors were used as an input to the

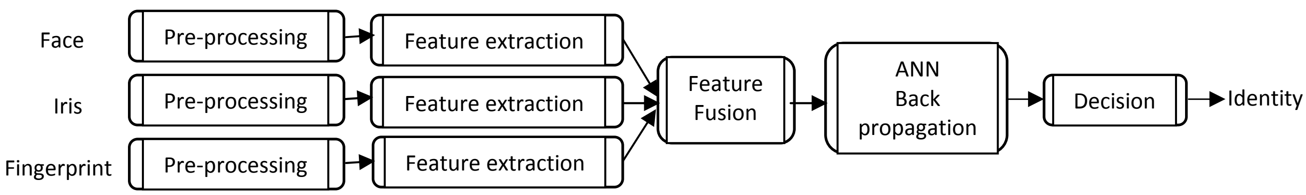

Figure (1) block diagram of the proposed system

neural network for training. For each subject, three samples for each trait were used in training phase and two samples for testing. The basic block diagram for the system is shown in figure (1). The steps for this work was the capturing of the traits, preprocessing, feature extraction, feature fusion, pattern recognition and finally the matching process where the identifying results is produced.

2.1 Database

Face, iris and fingerprint were used in this model. These traits were used because they are accepted by users since the capturing procedure is fast and easy, in addition all three traits are distinguished and unique for each person. Three different sources of database will be used to provide the required images for each trait. For face images the AT&T Laboratories / Cambridge face database will be used. The iris patterns have a wonderful and rich structure and are full of complex textures in contrast to other physiological characteristics. The iris is the colored region of the eye surrounded by the pupil and sclera. It is unique for each person. The CASIA Iris Image Database Version 1.0 (CASIA-IrisV1) "CASIA Iris Image D, http://biometrics.idealtest.org/" was used for this model. As for fingerprint, fingerprints are unique for each individual, they don't get affected highly by age and fingerprint scanning sensors are affordable and provide good image quality [8]. The database that was used is the CASIA Fingerprint Image Database Version 5.0 (or CASIA-FingerprintV5).

2.2 Preprocessing

Preprocessing the trait images helps enhancing the images and removes any noise that may occur during capturing of the traits. The preprocessing involves a number of image processing operation on the traits images.

Binarizing the face image using Otsu's global thresholding method is the first operation. For iris images, localizing the iris region is followed by normalization the iris by transforming the image from Cartesian to polar. Fingerprint preprocessing consisted of a number of morphological operations. After binarizing the image, dilation operation followed by erosion operation was performed. These operations help smoothing image contours and filling gaps in the fingerprint image that may be occurred after binarization. Thinning the image to a one bit width is the final step in fingerprint preprocessing.

2.3 Feature extraction

Holistic approaches, which means using global representations of the face was employed in this model. The appearance of the entire face image rather than on local features of the face will be used for face recognition.

Iris normalization is performed using Daugmans rubber sheet model [2]. Which transform the iris image from Cartesian form to a pseudo-polar form figure (2) shows iris normalization using the Daugmans rubber sheet operation.

For fingerprint, bifurcations and ridge ends will be extracted as fingerprint features. The number and direction of fingerprint bifurcations and ridges ends are unique for each person figure (3) shows samples of fingerprint, ridge ends and bifurcation. So, for this model the number for each bifurcation and ridge end will be calculated according to their orientations figure (4) illustrate some of the kernels used for extracting bifurcations and ridge ends.

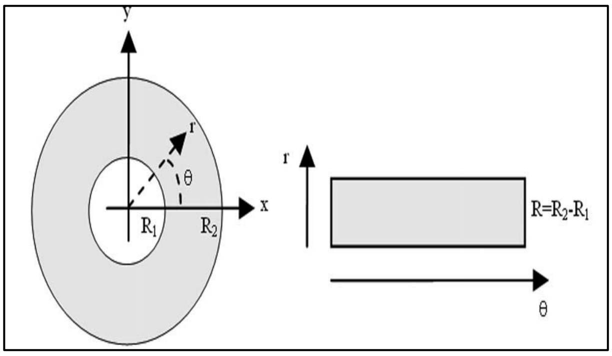

Figure (2) Iris normalization

Figure (3) Samples of fingerprint, ridge ends and bifurcation.

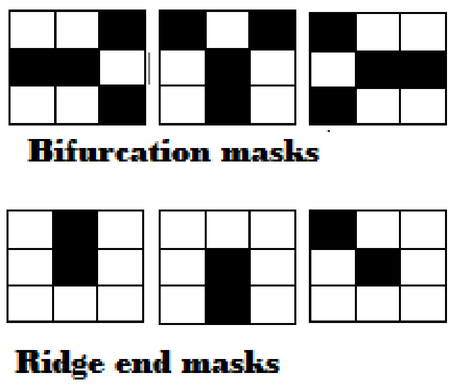

Figure (4) Bifurcations and ridge ends kernels samples

- **Wavelet Decomposition**

A signal can be decomposed using the wavelet decomposition method, there is an amount or percentage of energy that can be obtained from the wavelet bookkeeping vector and the wavelet decomposition vector [9]. Non-periodic signal analysis is best performed using Multi-Resolution Analysis (MRA) to analyze the frequency components of the signal [10].Using DWT, the signal is passed through a number of high pass filter and low pass filter. High frequency and low frequency components of the signal will be extracted this way. The low frequency contents of the signal are called the approximations while, the high frequency components of the signal are called the details. The approximate wavelet energy coefficients provide the information on the global image enhancement and detailed WE coefficients provide statistics on the image details.

The DWT pairs are given by

$$W_{\varphi}(j,k) = \frac{1}{\sqrt{M}} \sum x f(x) \varphi_{j_0,k}(x) \qquad (1)$$

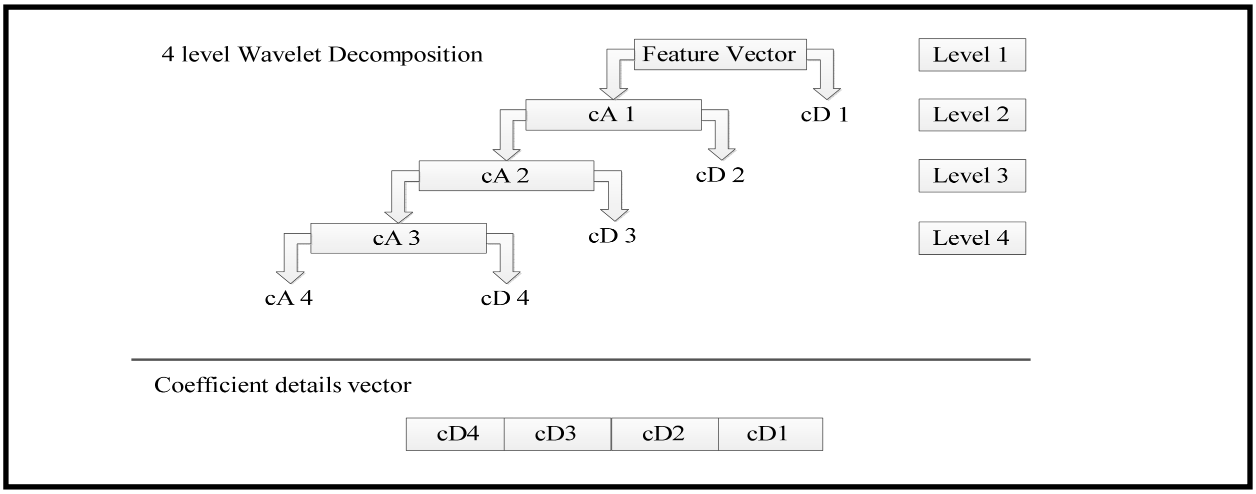

Figure (6) Four level wavelet decomposition and the creation of energy vector

$$W_{\Psi}(j,k) = \frac{1}{\sqrt{M}} \sum x f(x) \Psi_{j,k}(x) \qquad (2)$$

Where j>= j0 . Figure (6) shows a four level wavelet decomposition. This method serves two important tasks. It reduces the feature vector and it conserve the characteristics of the feature vector.

2.4 Feature fusion

The three vectors obtained for wavelet decomposition of the three traits will be fused to produce one feature vector. The extracted face, iris and fingerprint feature vectors from the previous stage will be fused by concatenating method. This will produce the final set of features for the next stage. Feature level fusion introduces two major limitation []. The first one is that the feature space is considered large and that leads to a more memory requirement. The second limitation, since different traits are used, each trait has a different feature vector shape and size. That's why it is called heterogeneous fusion. For this proposed model the use of wavelet decomposition solved both problems without affecting reducing the quality of the feature vector.

2.5 Pattern recognition

In order to learn the pattern of the features of the fused traits, pattern recognition techniques will be employed. Learning the patterns will help matching and identification process. The fused vectors of the training samples will be used to train both the neural network.

The proposed model uses the ability of neural network in learning patterns to recognize a pattern for the fused feature vectors. By learning patterns, the biometric model will be capable of identifying a person using face, fingerprint and iris features.

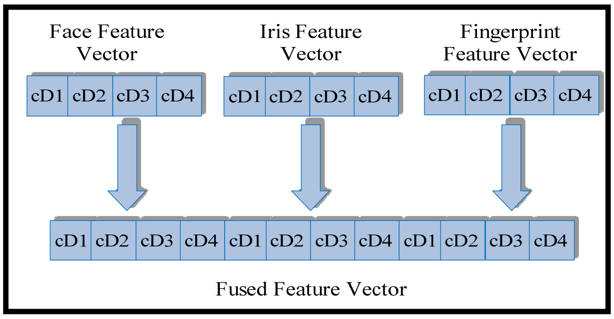

Figure (7) Feature Vector Fusion

Elman neural network with backpropagation was used. Input layer, two hidden layer and an output layer forms the structure of our proposed neural network.
Training the neural network with the fused feature will result a (12 x30) output pattern template. The template size for this model will be small and will not take a lot of memory space.

This is the advantage of using wavelet decomposition to reduce the vector size.

2.6 Matching

Identification will be performed by using different samples of the three traits of face, iris and fingerprint. Two samples for the three traits will be used for ten people. These trait will go through preprocessing, feature extraction and fusion. Samples will be tested individually and the identity of each person will be returned.

In order to find a match for the feature pattern (ICP) is used. The ICP procedure consists of an iterative process where the feature is brought closer to the matching feature. The ICP algorithm proposed by Besl and McKay (1992) has three basic steps [x]. First pair two points of P (x1, y1) and M (x2, y2), the Euclidean distance is applied [11]:

$$d(X,Y) = \sqrt{(x2-x1)^2 + (y2-y1)^2} \quad (3)$$

Then the motion that minimize the mean square error is computed between these two points.

$$E_{ICP} = \sum_i \|R.x_i + t - y_i\|^2 \quad (2)$$

Finally, optimal motion to point P is applied and the MSE is updated. Some iterations are needed to achieve a satisfactory solution.

3. EXPERIMENTAL RESULTS

This model was trained using three samples for each trait for ten subjects. The features of these traits were preprocessed. Wavelet decomposition was used as mean of feature extraction and a tool of compression to reduce the feature vector size. Neural network was used for pattern recognition. Two samples of these traits were used for testing the model. The identity was obtained after (ICP) was used to perform matching between the saved template and the tested feature patterns.

The FAR and FRR for the system were calculated as[12]:

$$FAR\ \% = \frac{false\ acceptance\ number}{total\ number\ of\ imposter\ tet}\ x\ 100\% \quad (5)$$

$$FRR\ \% = \frac{false\ rejection\ number}{total\ number\ of geniuen\ tet}\ x\ 100\% \quad (6)$$

The model showed a high accuracy with FAR of 0% and FRR of 3% . The recognition rate of this model was 85%

4. CONCLUSION

Multibiomatric authentication systems proved to be reliable and accurate for identification and verification purposes. With multibiometric, the system can achieve high accuracy with minimum required computational operation. Multilevel wavelet decomposition helped achieving a feature extraction and reduction at the same time. The small feature size led to a small template size which in turn helped ensuring that no large memory space is required.

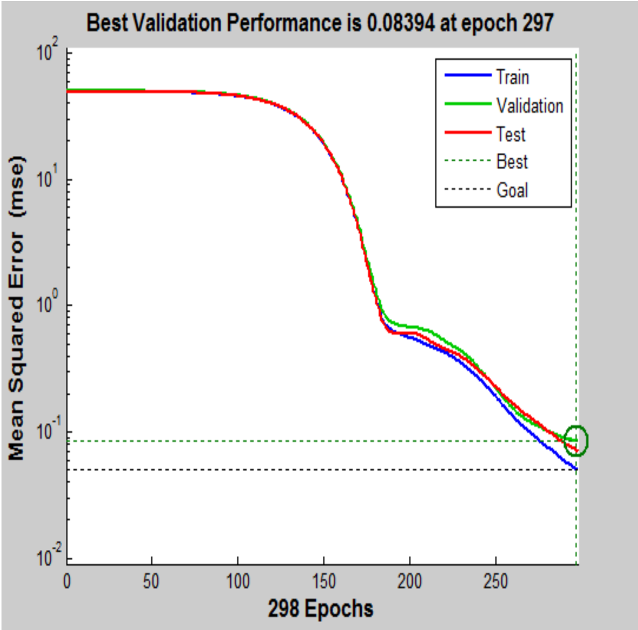

Figure (8) Neural Network performance graph

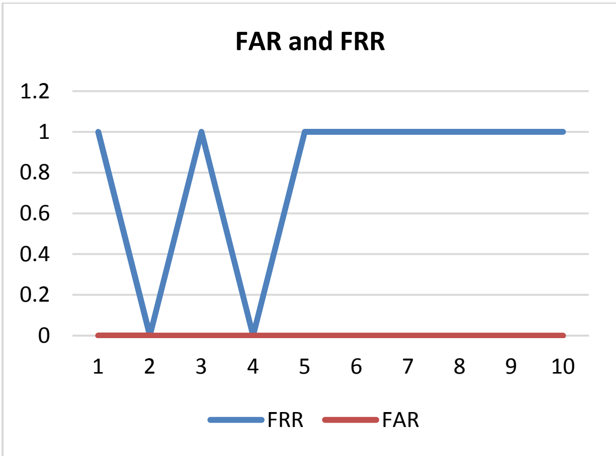

Figure (9) FAR and FRR of the proposed system

Table (1) Performance measurement of the system

Recognition rate	FAR	FRR
85%	0%	0.15%

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