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RESEARCH ARTICLE

Fingerprint Based Gender Classification Using Discrete Wavelet Transform & Artificial Neural Network

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Abstract— This research implements a novel method of gender classification using fingerprints. Two methods are combined for gender classifications. The first method is the wavelet transformation employed to extract fingerprint characteristics by doing decomposition up to 5 levels. The second method is the back propagation artificial neural network algorithm used for the process of gender identification. This method is experimented with the internal database of 550 fingerprints finger prints in which 275 were male fingerprints and 275 were female fingerprints. Overall classification rate of 91.45% has been achieved. Results of this analysis make this method a prime candidate to utilize in forensic anthropology for gender classification in order to minimize the suspects search list by getting a likelihood value for the criminal gender.

Keywords— Fingerprint, Discrete Wavelet Transform, Artificial Neural Network, Back propagation training, Gender Classification

I. INTRODUCTION

Each person has a unique fingerprint structure. Its uniqueness is developed for biometric authentication systems than others because fingerprints have advantages such as: feasible, differ from each other (distinct),permanent, accurate, reliable and acceptable Fingerprint identification algorithms are well established and are being implemented all over the world for security and person identity. Although Fingerprints are one of the most mature biometric technologies and are considered legitimate proofs of evidence in courts of law all over the world, relatively little machine vision method has been proposed for gender identification. This is helpful for anthropologists for classifying gender from the fingerprints they obtain from excavated articles and for crime investigators for minimizing the rage of the suspects. A fingerprint image is a pattern of ridges and valleys, with ridges as dark lines while valleys as light areas between the ridges. Ridges and valleys generally run parallel to each other and their patterns can be analyzed on a global and local level. Finger consists of different global and local features for matching purposes Studies so far carried out in gender determination have used generally ridge related parameters such as fingerprint ridge count, ridge density, ridge thickness to valley thickness ration, ridge width and fingerprint patterns and pattern types. All the methods proposed based on the fingerprint ridges have given insight about the ridge parameters mentioned about but fails to give accurate

method of measuring the parameters.[7][11] Let us have a brief introduction on wavlet transform and neural network.

A. Wavelet Transform

Before knowing wavelet transform let us know about the wavelets. A wavelet is a waveform of effectively limited duration that has an average value of zero. In mathematical term wavelets are mathematical functions that cut up data into different frequency components, and then study each component with a resolution matched to its scale. Fig.1 shows the comparison of wavelets with sine waves. Sinusoids extend from minus to plus infinity i.e. they do not have limited duration. Sinusoids are smooth and predictable whereas wavelets tend to be irregular and asymmetric. Wavelet analysis is the breaking up of a signal into shifted and scaled versions of the original (or mother) wavelet.

Fig.1 shows that signals with sharp changes might be better analyzed with an irregular wavelet than with a smooth sinusoid. Many kinds of wavelets exist can be chosen as per the requirement. The principle advantage is that they provide the advantage of knowing existence of a frequency at a particular time interval. Wavelet transform of any function f at frequency a & time b is computed by correlating f with wavelet atom as

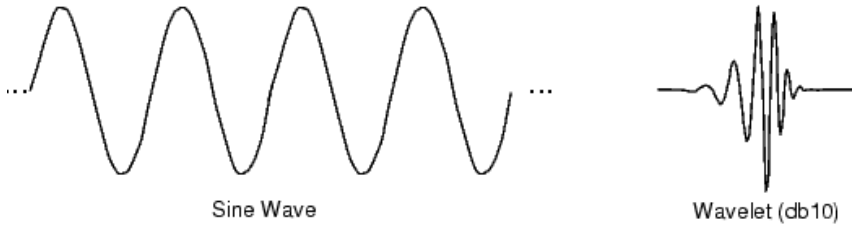

Fig. 1 Comparison of sine wave and wavelet

$$Wf(a,b) = \int_{-\infty}^{\infty} f(t)\,\Psi\left(t - \frac{b}{2}\right) dt$$

Wavelet transform is always defined in terms of a 'mother' wavelet ψ and a scaling function φ , along with their dilated and translated versions The use of wavelet transform on image shows that the transform can analyze singularities easily that are horizontal, vertical or diagonal which can be used in the fingerprint gender classification.

B. Artificial Neural Network (ANN)

Artificial Neural Network (ANN) or neural nets is an information processing paradigm that is inspired by the way biological nervous systems such as brain process information Neural networks are composed of highly interconnected processing elements called neurons operating in parallel to solve a specific problem. Neural networks are typically organized in layers. Layers are made up of a number of interconnected 'nodes' which contain an 'activation function'. Patterns are presented to the network via the 'input layer', which communicates to one or more 'hidden layers' where the actual processing is done via a system of weighted 'connections'. The hidden layers then link to a 'layer' where the answer is output. In a network, each connecting line has an associated weight. In a network, each connecting line has an associated weight.

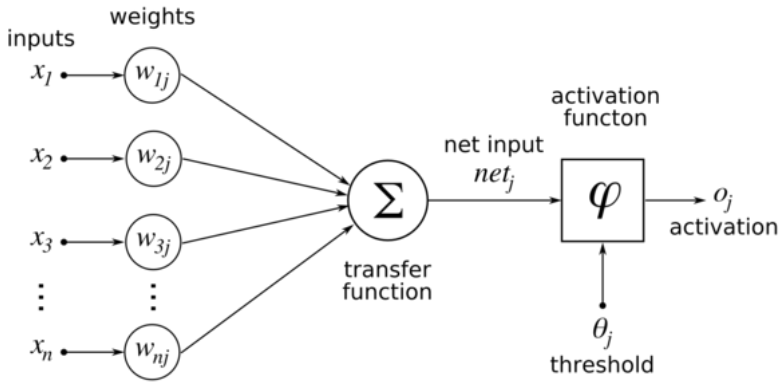

Figure 2 Neuron modal of artificial neural network

A neuron modal of artificial neural network is shown in the figure 2. Here x_1, x_2 ,x_3 ... x_n are the inputs and w_{1j} ,w_{2j} ,w_{3j}...w_{nj} are their corresponding weights. Activation function is applied to the net input and the output is produced. The output generated is shown by o_j. The connections between elements largely determine the network function. Neural networks are trained by adjusting the input weights ,so that a particular input leads to a specific target output. Figure 3 illustrates such a situation. There, the network is adjusted, based on a comparison of the output and the target, until the network output matches the target. Typically, many such input/target pairs are needed to train a network.

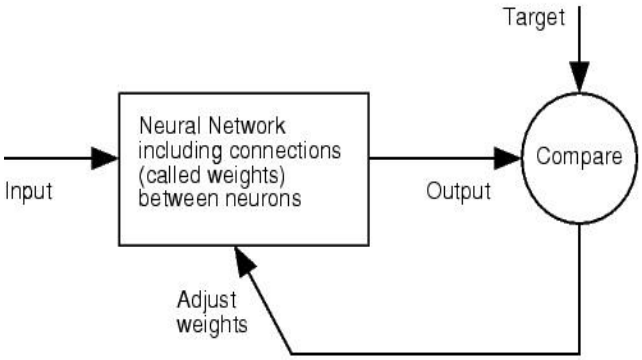

Figure 3. The basic structure of neural network

II. **PROPOSED SYSTEM**

The following paper aims in creating a system that is used to classify gender from an obtained fingerprint. We use 2D Discrete Wavelet Transform (DWT) and back propagation artificial neural network combined to classify gender using his/her fingerprint. The algorithm was implemented with MATLAB 7.10 using image processing toolbox, wavelet toolbox and neural network toolbox.

A. Fingerprint Image Acquisition

The fingerprint images of internal database were collected from a scanner manufactured by nitgen biometric solution. For this work a database with 550 images fingerprints was created which consisted of 275 male and 275 female fingerprints. Figure 4 shows nitgen biometric solution scanner used for collecting fingerprint images.

Figure 4 nitgen biometric solution scanner

B. Preprocessing

After collecting fingerprint samples, some preprocessing work such as background elimination, cropping, etc. have been carried out. All collected fingerprints are resized to 256x256. The fingerprint image obtained undergoes image enhancement for improving the visual appearance of an image or to convert the image to a form better suited for analysis by a human or a machine. Moreover fingerprint images contain noises caused by factors such as dirt, grease, moisture, and poor quality of input devices and are one of the noisiest image types. It is estimated that roughly 10% of the fingerprint encountered during verification can be classified as 'poor'. Therefore, fingerprint enhancement has become a necessary and common step after image acquisition. Figure 5 shows fingerprint images of different qualities.

Figure 5 Fingerprint images of different quality. The quality decreases from left to right.

C. DWT Feature Vector Generation

After preprocessing the enhanced fingerprint image undergoes discrete wavelet transformation upto 5 levels for obtaining the feature vector. During the wavelet transformation, frequency components in the image will be filtered out as approximations and details. The approximations are the high-scale, low-frequency components of the signal. The details are the low-scale, high-frequency components. Figure 7 shows the block diagram of feature extraction using DWT.

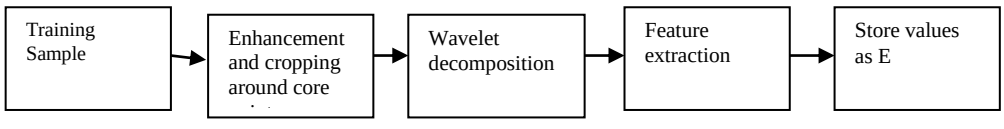

Figure 7 DWT based fingerprint feature extraction

Fingerprint image is decomposed into a multiresolution representation which keeps the least coefficients possible without losing useful image information. The 2-D wavelet decomposition of an image is results in four decomposed sub-band images referred to as low–low (LL), low–high (LH), high–low (HL), and high–high (HH). Each of these sub-bands represents different image properties. Typically, most of the energy in images is in the low frequencies and hence decomposition is generally repeated on the LL sub band only (dyadic decomposition). For k

level DWT, there are (3*k) + 1 sub-bands available. The energy of all the sub-band coefficients is used as feature vectors individually which is called as sub-band energy vector (E_k). The energy of each sub-band is calculated by using the equation :

$$E_K = \frac{1}{RC}\sum_{i=1}^{R}\sum_{j=1}^{C}|x_k(i,j)|$$

where $x_k(i, j)$ is the pixel value of kth sub-band and R, C is width and height of the sub-band respectively.

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Each fingerprint image undergoes five level decomposition after preprocessing as shown in Fig.6 . At each level we get subbands and their energy is calculated. We get a total of 16 subbands and the energy vector E_K will be 1x16 vector at the end of the five level decomposition for each fingerprint. All fingerprints in the database undergo the decomposition and the energy vector of all the images is stored .

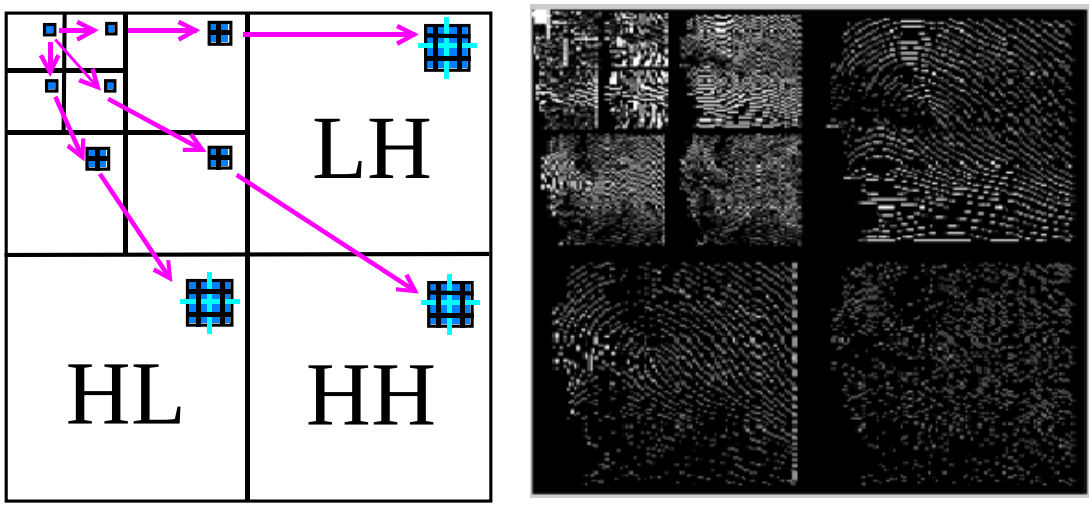

Figure 6 DWT decomposition of a fingerprint image

D. ***Backpropagation Training***

The characteristic of fingerprint stored in a database is used as the data for training backpropagation artificial neural network to find an optimal weight. Consequently, the number of input neurons is equal to the number of fingerprint characteristic stored in the database for 220 input neurons. Training process of backpropagation artificial neural network as illustrated by the block diagram shown in figure 7.

Artificial neural networks can be defined as a group of interconnected neurons used for information processing as a computation model. They are biologically inspired computer programs to simulate the way in which the human brain process information. It is an adaptive system capable of transforming its arrangement according to input and output sequence that flows in the network In this paper we are using LMBP (Levenberg-Marquardt back propagation algorithm). This method trained arbitrary-sized data set and seems fastest technique for feed forward neural networks.

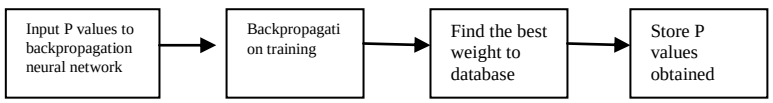

Figure 7 Training stage of the proposed gender classification system

Training the back propagation network requires the following steps:

1. Apply the vector obtained from the training data set as input to the network.
2. Calculate the output of the network.

3. Calculate the error between the network output and the desired output set as the target vector T.
4. Adjust the weights of the network in a way that minimizes the error.
5. Repeat the steps 1 through 4 for the training set until the error for the entire set is acceptably low.

The system consists of inputs P and targets T to be solved with a network. Here a network is created with six hidden layers with different number of neurons in each layer. The network is simulated and its output is generated against the target.

III. GENDER CLASSIFICATION

We have used 275 male fingerprints and 275 female. The fingerprints of both classes are grouped and kept as the database fingerprints. Steps to be followed for Gender classification using the query fingerprint:

1. Input Query fingerprint whose gender has to be classified from the database.
2. The fingerprint undergoes pre processing and is resized to 256x256.
3. The fingerprint undergoes Wavelet Decomposition and the 16 feature vector is obtained.
4. Feature vector is obtained from wavelet decomposition is given as input to artificial neural network to generate an output.
5. Threshold is set to TH. Rule is set in such a way that if the output generated is greater than TH the decision is female and if the output generated is less than TH the decision will be male.

IV. PERFORMANCE ANALYSIS

In this experiment we have taken 1000 epochs and the training was completed in 98 iterations. The network is trained through Feed-forward back propagation algorithm. Figure displays the training progress of the network. The performance in terms of mean squared errors and the is also shown in the figure. The figure shows the performance curve produced while training, testing and validation of the network. We get the Best Validation Performance 0.019281 at 92 epoch**.**

Recognition Rate for fingerprint database is calculated as:

$$\% \text{ Recognition Rate} = \frac{\text{Total No. of correctly recognized Fingerprint samples}}{\text{Total No.of fingerprint samples}}$$

$$= \frac{503}{550} \times 100 = 91.4545$$

The overall success rate in gender classification is 91.45% for our database.

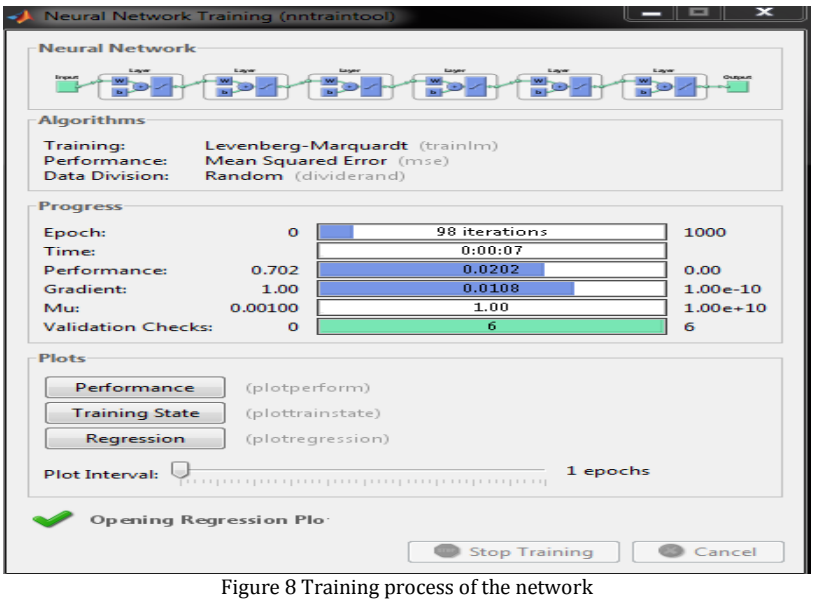

Figure 8 Training process of the network

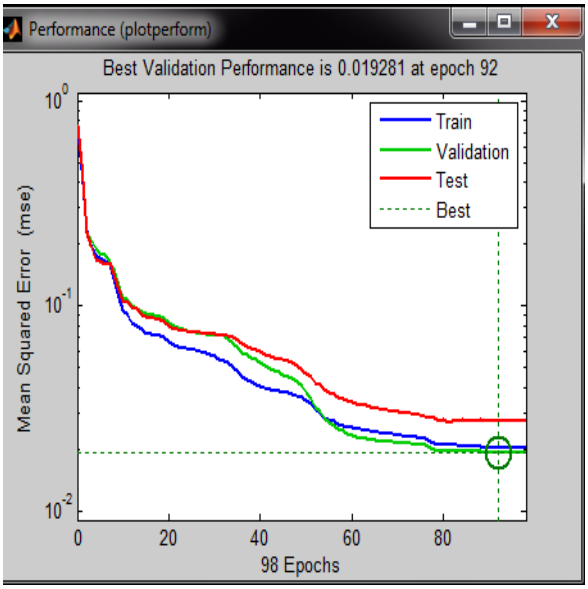

Figure 9 performance plot in terms of mean square error

V. CONCLUSION

Once a person is identified as male or female, then any suitable biometric trait can be used for further classification. Identification of gender can also provide an important clue in various security and surveillance based applications. Fingerprint evidence is undoubtedly the most reliable and acceptable evidence till date in the court of law. Due to the immense potential of fingerprints as an effective method of identification, an attempt has been made in the present work to analyze their correlation with gender of an individual. Wavelets have been used frequently in image processing and used for feature extraction; Neural Network classifier has a higher classification rate than LDA and FCM. Gender classification results showed that this method could be considered as a prime candidate for use in forensic anthropology in order to minimize the suspects search list and give a likelihood probability value of the gender of a suspect.

VI. FUTURE SCOPE

In future, the work will be extended to build robust algorithm for frequency domain and region properties to find different parameters (like age group, Rural, Urban people) and different features it can be applied in gender classification which will be more accurate and suitable for all types of applications In future, more work can be done in frequency domain to find different parameters and different transforms that can be applied in gender identification which will more accurate and suitable for all types of applications.

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