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Fingerprint Recognition using Fuzzy Back Propagation Neural Network

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***Abstract*—**Fingerprint is the most widely used form of biometric system. Every person has a unique fingerprint and it is stable over the person's lifetime. In this paper a fingerprint verification system using invariant moment features and Back Propagation Neural Network is proposed. For extracting good quality features, the quality of the image is to be improved through enhancement. The acquired image is enhanced using Short Time Fourier Transform (STFT). A unique core point is then detected from the enhanced image by using complex filters to determine a Region of Interest (ROI), which is centered at the enhanced image. Finally a total of four sets of seven invariant moment features are extracted from four partitioned sub-images of an ROI. To measure the similarity between feature vectors of an input fingerprint with the template stored in the database, the Fuzzy Back Propagation Neural Network is employed for FVC2002 dataset.

Keywords—biometrics; BPN; fingerprint; fuzzy; invariant moment; STFT

I. INTRODUCTION

Identifying an individual based on certain physiological or behavioral characteristics is Biometry. Biometrics is important in security systems and is under consideration in order to minimize security threats in military organizations base, government centers and public places like airports [1]. The suitable biometrics can be selected depending upon the application in various computer based security system. Among all the biometrics, fingerprint is a great source for identification of individuals. Fingerprints have been used in Forensic Science for a long time for personal identification. This is because the fingerprints of an individual are unique and do not change throughout one's life. This makes them an ideal signature of a person [2].

Fingerprints are developed at fetal stage and do not change throughout one's in life. Among all the biometric traits, fingerprint identification is well developed. The uniqueness, immutability and low cost of fingerprint system is to be most widely used and being universally accepted as the best identification system [3]. All the biometric indicators, fingerprints have one of the highest levels of reliability and have been extensively used by forensic experts in criminal investigation [1].

The accuracy of the fingerprint authentication system is greatly influenced by the quality of features extracted from the enhanced fingerprint image. Two main categories of the fingerprint verification system are minutiae based methods [3] and image based methods [4]. In the minutiae based method, a feature vector is extracted for each fingerprint and it contains the position, orientation as well as the type of the minutiae points. The minutiae based method may not use the rich discriminatory information available in the fingerprints and it is complex.

Moment invariants have been widely applied to image pattern recognition in a variety of applications due to its invariant features on image translation, scaling and rotation. Moment invariants are first introduced by Hu [5]. Ju Cheng Yang and Dong Sun Park implemented a fingerprint verification system based on a set of invariant moment features and a nonlinear BPNN is proposed. For overcoming the above discussed method [1].The biometric fingerprint recognition involves preprocessing, feature extraction and finally matching as shown in fig.1.

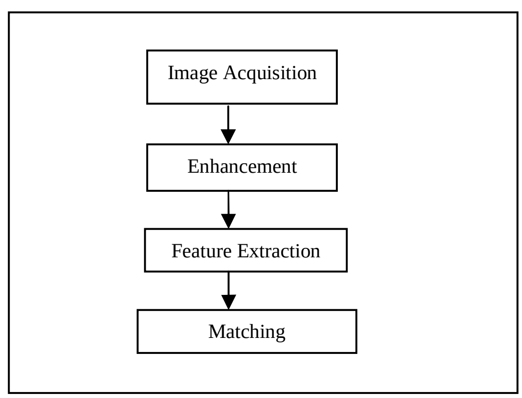

Fig. 1. Biometric Fingerprint Recognition

In this research work the fingerprint image is recognized using Fuzzy BPN. Initially the acquired image is enhanced using Short Time Fourier Transform (STFT). A unique core point is then detected from the enhanced image by using complex filters to determine a Region of Interest (ROI), which is centered at the enhanced image. A total of four sets of seven invariant moment features are extracted from four partitioned sub-images of an ROI.

The paper is organized as follows. In section II, the fingerprint image is preprocessed using STFT enhancement analysis and complex filter. A set of invariant moment features are extracted from the centre of the cropped image centers the position of the reference point in Section III. Section IV provides the experimental results of the proposed method. Section V concludes with some research perspectives.

II. PREPROCESSING

The fingerprint recognition system mainly consists of image enhancement, feature extraction and matching.

A. *STFT Enhancement*

A fingerprint image is first preprocessed to enhance an original image by Short Time Fourier Transform (STFT) analysis. The performance of a fingerprint matching algorithm depends critically upon the quality of the input fingerprint image. The fingerprint image may be thought of as a system of oriented texture with non-stationary properties. Fourier analysis is not adequate to analyze the image completely. The STFT of 1D signal x(t) is now represented by time frequency atoms X(τ, ω) [2].

$$\mathbf{X}(\tau,\omega) = \int_{-\infty}^{\infty} \mathbf{x}(t)\, \mathbf{W}^*(t-\tau) e^{-j\omega t} dt \qquad (1)$$

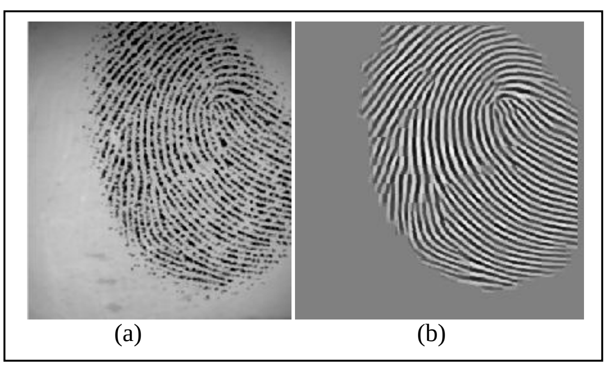

Fig.2. Fingerprint Enhancement using STFT: (a) Original image; (b) Enhanced image

In the case of 2D signals such as a fingerprint image, the space-frequency atoms is given by,

$$\mathbf{X}(\tau_1,\tau_2,\omega_1,\omega_2) = \int_{-\infty}^{\infty}\int_{-\infty}^{\infty} \mathbf{I}(x,y)\, \mathbf{W}^*(x-\tau_1)(y-\tau_2) x e^{-j(\omega_1 x+\omega_2 y)} dxdy \qquad (2)$$

The enhanced image using STFT is depicted in figure 2.

B. *Complex filter*

Complex filter, of order m, can be modeled by where I is the imaginary unit, m is an integer and φ is the orientation angle. Using polynomial approximation on these complexes filters produce; here g is a Gaussian defined as below and x and y are the coordinates.

$$g(x,y)=\exp\left(-\frac{x^2+y^2}{2\sigma^2}\right) \qquad (3)$$

Core pattern and delta pattern are two kinds of orientation patterns in fingerprint images. The complex filter response is formulated as, μ represents the degree of symmetry; α is the geometric orientation of the symmetric pattern. If $|\mu 1| > T1$, the fingerprint is the core type. If $|\mu 2| > T2$, then it is type delta. The magnitude response of the filter is sharpened using the following rules, where k = 0, 1, 2, 3.

$$S_{1k}=\mu_{1k}(1-\mu_{2k}) \qquad (4)$$
$$S_{2k}=\mu_{2k}(1-\mu_{1k}) \qquad (5)$$

to implement this algorithm, the scalar product (h, z) is then calculated; we use the following equation to obtain h, where h indicates the complex filter order m, and z is the complex orientation field [6].

$$\mathbf{h} = (x+iy)^m g(x,y) \qquad (6)$$

C. *Determination of reference point*

We determine the reference point from the enhanced image. The reference point is defined as “the point of the maximum curvature on the convex ridge,” which is usually located in the central area of fingerprint. It will detect using complex filtering methods [1].Figure 3Shows the ROI extraction from the enhanced image.

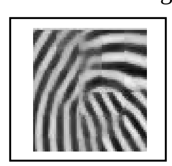

Fig.3. ROI detection from the enhanced image

III. INVARIANT MOMENT FEATURE EXTRACTION

3.1 Geometric Moment

The geometric moment invariants produce a group of features vectors that are invariants under shifting, rotation and scaling. Regular moment invariants are most popular counter-based description derived by Hu.The two-dimensional geometric moment of order (p+ q) of a function f(x, y) is defined as

$$M_{pq} = \int_{a_1}^{a_2} \int_{b_1}^{b_2} x^p y^q f(x,y)\,dx\,dy, \quad \textbf{(7)}$$

Where p, q=0, 1, 2 …∞.

3.2 Moment Invariants

The method of moment invariants is derived from algebraic invariants applied to the moment generating function under a rotation transformation. The set of absolute moment invariants consists of a set of nonlinear combinations of central moments that remain invariant under rotation.

Hu defines the following seven functions, computed from central moments through order three, that are invariant with respect to object scale, position and rotation. We used moment analysis to extract invariant features from partitioned sub-images in an ROI.

$$\phi_1 = \eta_{20} + \eta_{02},$$
$$\phi_2 = (\eta_{20} - \eta_{02})^2 + 4\eta_{11}^2,$$
$$\phi_3 = (\eta_{30} - 3\eta_{12})^2 + (3\eta_{21} - 3\eta_{03})^2,$$
$$\phi_4 = (\eta_{30} + \eta_{12})^2 + (\eta_{21} + \eta_{03})^2,$$
$$\phi_5 = (\eta_{30} - 3\eta_{12})(\eta_{30} + \eta_{12})[(\eta_{30} + \eta_{12})^2 - 3(\eta_{21} + \eta_{03})^2] + (3\eta_{21} - \eta_{03})(\eta_{21} + \eta_{03})[3(\eta_{30} + \eta_{12})^2 - (\eta_{21} + \eta_{03})^2],$$
$$\phi_6 = (\eta_{20} - \eta_{02})(\eta_{30} + \eta_{12})[(\eta_{30} + \eta_{12})^2 - (\eta_{21} + \eta_{03})^2] + 4\eta_{11}(\eta_{30} + \eta_{12})(\eta_{21} + \eta_{03}),$$
$$\phi_7 = (3\eta_{21} - \eta_{03})(\eta_{30} + \eta_{12})[(\eta_{30} + \eta_{12})^2 - 3(\eta_{21} + \eta_{03})^2] + (3\eta_{12} - \eta_{30})(\eta_{21} + \eta_{03})[3(\eta_{30} + \eta_{12})^2 - (\eta_{21} + \eta_{03})^2]. \quad \textbf{(8)}$$

The function ϕ_1 through ϕ_6 are invariant with respect to rotation and reflection while ϕ_7 changes sign under reflection [1]. The feature extraction value sample is given below.

Table1. Seven moments with the different sub-images of the FINGERPRINT IMAGE (M= Invariant Moment, I=sub-images)

	I_1	I_2	I_3	I_4
M_1	6.659714	6.653635	6.662685	6.661865
M_2	20.20554	22.17764	19.95373	19.95373
M_3	25.54887	28.61435	27.35306	27.35306
M_4	30.12149	29.69914	28.87533	28.87533
M_5	58.0675	60.01646	57.39719	57.39719
M_6	40.60153	40.83938	39.97735	39.97735
M_7	59.20406	59.04041	57.90297	57.90297

IV. EXPRIMENTAL RESULTS

4.1 Backpropagation Neural Network

Back propagation training algorithm is a supervised learning algorithm for multilayer feed forward neural network. Both input and target output vectors are provided for training the network. A network with a single real input x and network function F. The derivative F'(x) is computed in two phases:

Feed-forward: the input x is fed into the network. The primitive functions at the nodes and their derivatives are evaluated at each node. The derivatives are stored.

Back propagation: the constant 1 is fed into the output unit and the network is run backwards. Incoming information to a node is added and the result is multiplied by the value stored in the left part of the unit. The result is transmitted to the left of the unit. The result collected at the input unit is the derivative of the network function with respect to x [7].

The training algorithm of back propagation involves four stages,

- Initialization of Weights
- Feed forward
- Back propagation of errors
- Updation of weights and bias

Finally, a set of outputs is produced as the actual response of the network. During the forward pass the synaptic weights of network are all fixed. And the other hand backward pass the synaptic weights are all adjusted in accordance with the error correction rule.

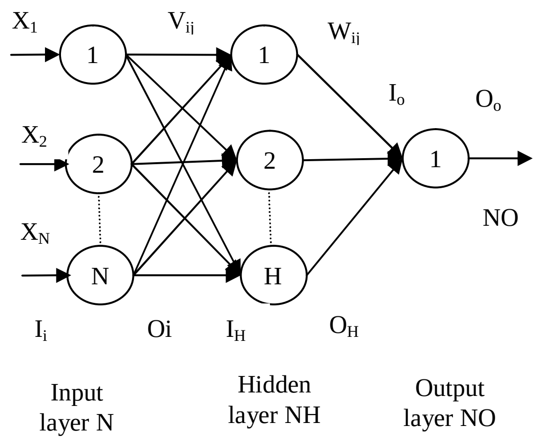

Fig.4. The Structure of BPNN

4.2 Fuzzy BPNN

In fuzzification, two input variables are antecedents and output variable is used as consequence in the fuzzy control. It is methodology that lends itself implementation in systems ranging from small embedded micro-controllers to large control systems [8].

The LR-type fuzzy numbers are special type of fuzzy numbers, proposed by Dubois and Prade. A fuzzy number is of there exist reference function L (for left), R (for right) and scalars, $\alpha > 0$ and $\beta > 0$ is a real number. Here α and β are called the left and right. The LR-type function indicates a crisp value.

4.3 Matching process

A set of three-layer BPNN are used to verify a matching between feature vectors of input fingerprint and those of a template fingerprint. For each input fingerprint and its template fingerprint, we compute maximum, minimum and average as the input of the BPNN.

In the experiments of BPNN matching, 80 BPNN each with 3 input layer neurons and 1 output layer neurons. The whole feature value is given to the training process and testing.

V. CONCLUSION

In this paper, the fuzzy neural network is proposed for fingerprint recognition. Initially the fingerprint image is enhanced using STFT. The complex filter is used to locate the core point from the enhanced image. The ROI is extracted based on the core point which is centered at the enhanced image. A set of invariant moment features are extracted from partitioned sub-images of an ROI .The proposed method has better performance in matching for FVC2002 dataset.

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