*IEESE International Journal of Science and Technology (IJSTE), Vol . 1, No. 1, March 2012,12-17*
*ISSN : 2252-5297*

# Fingerprint Identification System Using Wavelet Transform And Artificial Neural Network

Ahsanun Naseh Khudori[1], Muhammad Faisal[2], Ririen Kusumawati[3]

[1.2.3.] Information Technology Department Faculty of Science and Technology
Maulana Malik Ibrahim State Islamic University
Jl. Gayana No. 50 Malang
**Indonesia**
E-mail: ahsanunnaseh@yahoo.com, muhfais@yahoo.com

***Abstract.*** *This research implements two methods to perform fingerprint processing. The first method is the wavelet transformation used for the fingerprint feature extraction. The second method is the back propagation artificial neural network algorithm used for the process of fingerprint identification. Fingerprint data sample is obtained from the website at http://www.bias.csr.unibo.it/fvc2004.databases.asp which can be downloaded for free. Wavelet transformation function to extract fingerprint characteristics by doing the decomposition for 4 levels. From the result of the decomposition, the coefficient having the greatest magnitude (low-frequency images) for 8x8 pixels is taken. This Characteristic is stored into the database My SQL to be inputs for back propagation artificial neural network. They are 64 input neurons.*

*Input system is the fingerprints image and as the fingerprint identification of the owner (id, name, and address.). At the beginning of processing, the fingerprint is converted to be grayscale image. Then, it is changed to be YIQ color space, and only luminance Y as the gray factor of image is taken. To find the best combination of algorithm parameter of the artificial neural network, it is done by testing combination of parameters repeatedly. As the result, the best parameter combination with learning rate = 0.1, hidden layer neurons= 125 neurons with 15 fingerprint data is good .This parameter produces the good introduction of back propagation artificial neural network for 86.6%. From the best result of parameter combination, it is used to test the influence of the number of fingerprints toward the recognition. The result of the experiment shows that artificial neural network performance decreases along with the increasing number of fingerprint data being tested.*

Key-Word: *Fingerprint, Wavelet, and Artificial Neural Network*

## 1. 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 (*distinc*), permanent, accurate, reliable and acceptable[1].

In the human's fingerprint, a prominent part in the form of streaks or lines is called the hill, while the flat one that separates the prominent parts one another is called the valley. Figure 1. shows fingerprints, hills, and valleys on its fingerprint.

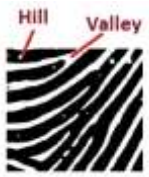


**Figure 1.** Hill and valley of Fingerprint

Wavelet is one of the image processing methods that can extract fingerprint features. With wavelet transform, the important features will not be lost when the dimensions of the image is reduced. Wavelet actually comes from the scale function. The concept of the transformation is simple. The original image is decomposed into 4 sub-new images. Each sub-image has ¼ times of the original image size. 3 sub-images spread at the upper right position, right bottom , and left bottom which is as a rough version (high-frequency image) of the original image. On the other hand, the upper right position is a soft version and it looks like the original image (low-frequency image). The grand wavelet used is haar wavelet because it is the easiest to use [2]. In contrast, the processing of fingerprint identification uses the backpropagation artificial neural network. The propagation artificial neural network is reused because it has a multilayer architecture in order to solve a complex problem[3].

Rashid, M.M et.all had researched about fingerprint verification system using neural network. Fingerprint recognition is based on the fingerprint minutiae. The result showed that the artificial neural network works well[4].

## 2. Material and Method

### 2.1 Tools and Material

We implemented our research using 1 unit of computer, Netbeans 6.9.1, My-SQL data base, and fingerprint data. This research will be built with java language.

### 2.2 Method

Fingerprint identification system consists of two main modules; registration module and identification module. Registration module is a module which is required by the system to process the fingerprint. It results features and then is stored in the database along with the identity of the owner of the fingerprint. On the contrary, the identification module is a module which is used to find the library image in the database.

Fingerprint enrollment process is described by the block diagram as follows:

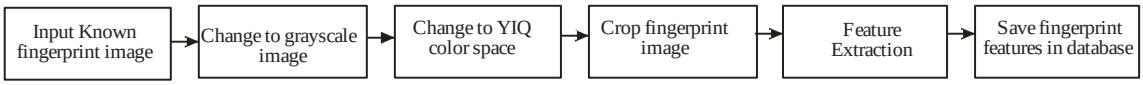


**Figure 2.** Block diagram of the Registration process

Fingerprint features that have been stored in the database are used as the input of training process of backpropagation artificial neural network as illustrated by the block diagram below:


**Figure 3.** Block diagram of the training process

The process of identification is shown by the block diagram as follows:

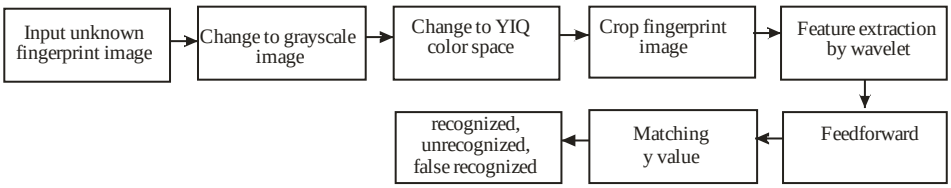


**Figure 4.** Block diagram of the identification process

### 2.2.1. Fingerprint collection

The fingerprint data is obtained from the internet at http://www.bias.csr.unibo.it/fvc2004/databases.asp. At this site, there is a collection of fingerprint database that can be freely downloaded by the researcher. The fingerprint data is 300 x 300 pixels.

### 2.2.2. Preprocessing

Preprocessing is begun by putting the fingerprints into the system. Then, the fingerprint is converted to a grayscale image. It is the image which only has one value for channel at each pixel. The conversion to grayscale image is done by taking and adding up the value of RED, GREEN, BLUE and divided by 3. Furthermore, the fingerprint image is converted to YIQ color space, and just taken the luminance Y. Y coordinate represents the luminance, while the I and Q represent the hue and saturation. The relation system of YIQ with Rn, Gn, Bn system is a linear transformation as follows:

$$\begin{bmatrix} Y \\ I \\ Q \end{bmatrix} = \begin{bmatrix} 0.299 & 0{,}587 & 0.114 \\ 0.596 & -0.275 & -0.321 \\ 0.212 & -0.523 & 0.311 \end{bmatrix} . \begin{bmatrix} \mathrm{R}n \\ \mathrm{G}n \\ \mathrm{B}n \end{bmatrix}$$

Then, the fingerprint is cropped for 256 x 256 pixels to be processed with wavelet transform.

### 2.2.3. Feature Extraction

Wavelet actually comes from the scale function. The concept of the transformation is simple. The original image is decomposed into 4 sub-new images. Each sub-image has ¼ times of the original image size. 3 sub-images spread at the upper right position, right bottom , and left bottom which is as a rough version (high-frequency image) of the original image. On the other hand, the upper right position is a soft version and it looks like the original image (low-frequency image).

The process of transformation can be done by convolution or averaging process and a reduction in many times often called as the method of filter banks. Wavelet transformation on two-dimensional image is illustrated in figure 5. below.

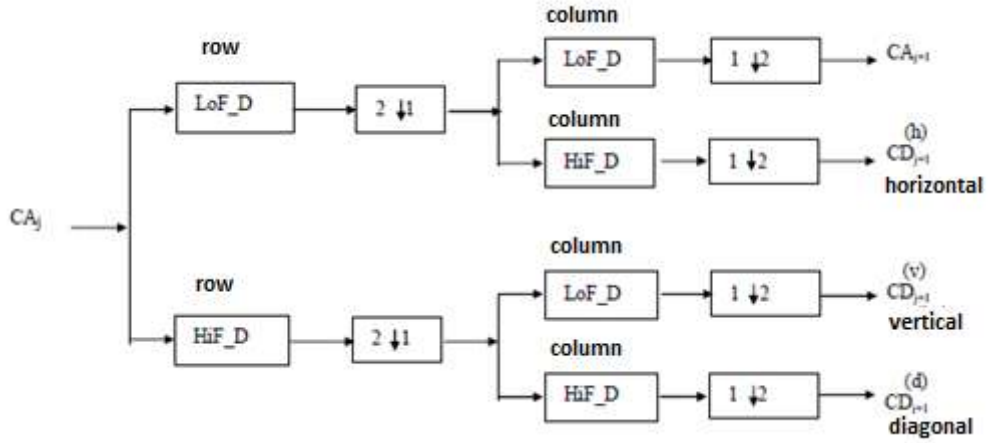


**Figure 5.** Two Dimensional Wavelet Transforms.

Explanation:

| | |
|---|---|
| 2↓1 | Column's down sample : skip even column index |
| 1↓2 | Row's down sample : skip even row index |
| row X | Row vector convolution with filter X |
| column X | Column vector convolution with filter X |

LoF_D : Low frequency filter for decomposition
HiF_D : High frequency filter for decomposition
LoF_R : Low frequency filter for reconstruction
HiF_R : High frequency filter for reconstruction

In this research, the fingerprint characteristics are selected from the results of wavelet transform having low coefficient (approximation coefficients). The decomposition is done for 4 levels resulting in a fingerprint image for 16 x 16 pixels with a low-frequency image for 8 x 8 pixels. Theoretically, the image with low frequentation from the wavelet transform is the image that represents the original image.

### 2.2.4. Backpropagation

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 64 input neurons. The weight of the network is initialized with random manner[6]. In many studies, convergence will not be achieved if the weight is less varied[7]. The convergence is almost always achieved for random initialization -0.5 to 0.5-to 1 or -1. In this research, the weights were randomly initialized in numbers -0.5 to 0.5. The process of backpropagation training algorithm is as follows:

### 2.2.4.1. Phase 1, feedforward

At the feed forward phase, the input signal ($x_1$) is propagated to the hidden layer using the specified activation function. The output of each hidden layer unit ($z_j$) are then propagated forward to the hidden layer on it using activation of Binary Sigmoid function. It is also done for the next output to produce a network output ($y_k$). Then, the network output ($y_k$) is compared with the target to be achieved ($t_k$). The difference between $t_k - y_k$ is the error that occurred. If the error is smaller than the specified tolerance limits, then iteration is stopped. However, if the error is still greater than the tolerance limit, then the weight of each line in the network will be modified to reduce the errors that occurred.

### 2.2.4.2. Phase 2, backforward.

Based on the error of $t_k$-$y_k$, it is calculated to be the factor δk (k = 1,2, ...., m) used to distribute the error $y_k$ unit to all hidden units connected directly to the $y_k$. The Δk is also used to change the weight of the line that relates directly to the output unit. With the same method, it is calculated for the factor $\delta_j$ hidden in each layer as the basis of weight changes for all the lines coming from the unit hidden beneath its layer. It is done for the others so that all the factors δ in hidden unit directly related to the input unit which is calculated.

### 2.2.4.3. Phase 3, delta weights

After all the factors δ calculated, the weight of all the lines is simultaneously modified. The change of a line is based on the factor δ of neurons above its layer. For example, change in the weight of the lines leading to the layer output is based on δk in output units.
All phases (phase 1, 2, and 3) are repeated until the termination condition is got. In this research, the termination condition often used is number of iteration and error. Iteration will be terminated if the number of iteration performed exceeds the specified maximum number of iterations, or if the error is smaller than the minimum allowable error.

### 2.2.5. Matching Process

Fingerprint matching is done by inputting a fingerprint image in which the owner of it is unknown to the system. Fingerprint image is processed in the same way at the registration process (conversion to grayscale images, conversion to YIQ color space, and feature extraction). The characteristic produced in the process of feature extraction is used as input to the artificial neural network for the matching process. Matching process is limited to the first feed-forward step using the optimal weight of training result. Feedforward output ($y_k$) at the time of testing is compared to the output $y_k$ at training. The system will search for library images having a value $y_k$ which is adjacent or similar.

## 3. Results And Discussion

The test application is done by inputting 15 fingerprint data with the identity of fingerprint owner's to a system that has been created. Testing is done to get the right combination of parameters for artificial neural network learning. These parameters are combined to produce a combination parameter according to the author is optimal used in the learning process in artificial neural network. Maximally, a parameter is based on the speed in making learning applications (the least epoch) and the combination of a minimum number of small errors.

The number of layers greatly affects the performance of the network. Kanata proved that the number 4 and 5 layers of computation in the network is very hard [8]. Thus, this research focuses on three layers with one hidden layer. Parameters tested in this research are as follows:

**Table 1**. Parameter test

| No | Characteristics | Specification |
|---|---|---|
| 1 | Architecture | 1 Hidden Layer |
| 2 | The number of Input Neuron | The number of image dimension |
| 3 | The number of Input Neuron | The number of fingerprint tested |
| 4 | The number of Hidden Layer | 25, 50, 75, 100, 125, 150, 175, 200 |
| 5 | The speed of Training | 0.1,0.2,0.3,0.4,0.5 |
| 6 | Function of Activation | Sigmoid Biner |
| 7 | Galat | 0.01 dan 0.1 |

The first trial is conducted to find the best number of hidden layer. The tests is conducted with 15 fingerprint data and learning rate 0.1. The test is carried out repeatedly by the number of hidden layer 25, 50, 75, 100, 125, 150, 175, and 200.

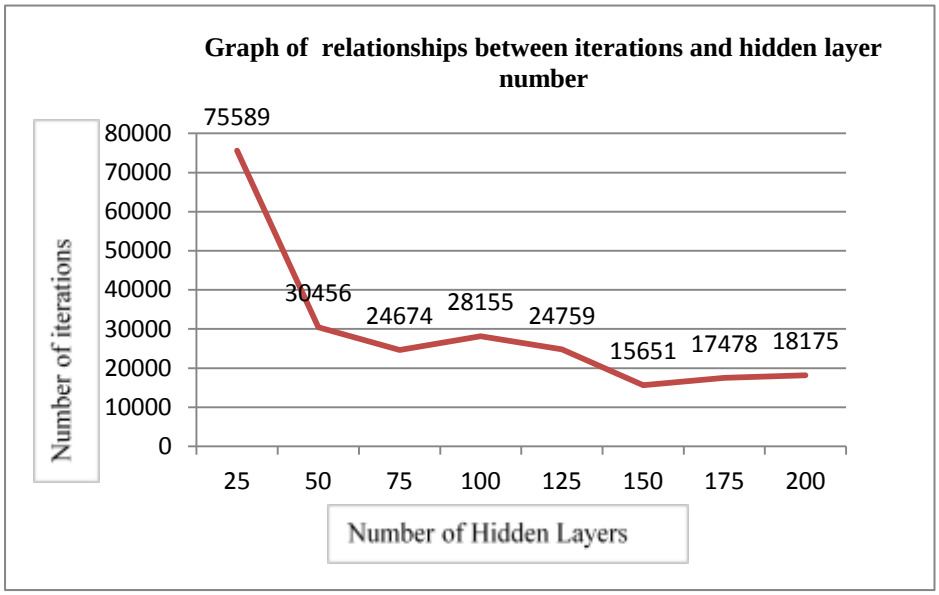


**Figure 6.** Graph of relationships between iterations and hidden layer number

From the result of the test, it can be seen the tendency that the smaller the number of hidden layer, the number of iterations will be many more. At the time of testing, it is produced the best hidden layer, the hidden layer with 15 651 150 iterations.

The second trial is conducted to find the best learning rate. The test is conducted with 15 fingerprint data and learning rate 0.1. The test is done repeatedly with the learning rate 0.1,0.2,0.3,0.4, and 0.5. The percentage of the performance is calculated by the formula:

$$\text{Successful fingerprint identification} = \frac{\text{The number of fingerprints identified}}{\text{Number of fingerprints tested}} \text{ x } 100\ \%$$

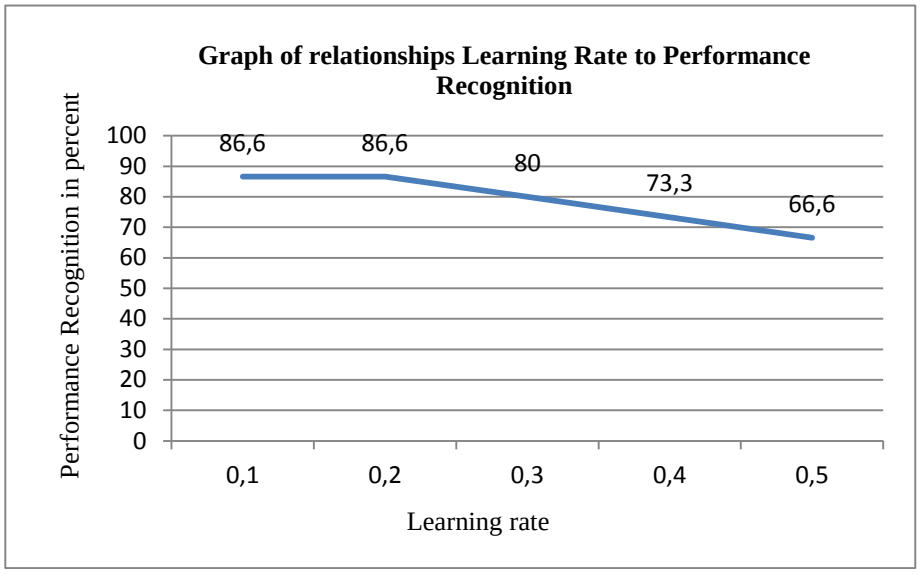


**Figure 7.** Graph of relationships learning rate to performance recognition

The result of the test indicates that a reduction in the rate of initial training 0.1 and 0.2 provides the best performance, ie 86.6%. From the first and the second trial, it is got the hidden layer and the best learning rate, ie

125 and 0.1 or 0.2. Then, the network is tested with a number of input fingerprints which are different one another using the input number 15, 30, 50, and 75 fingerprints.

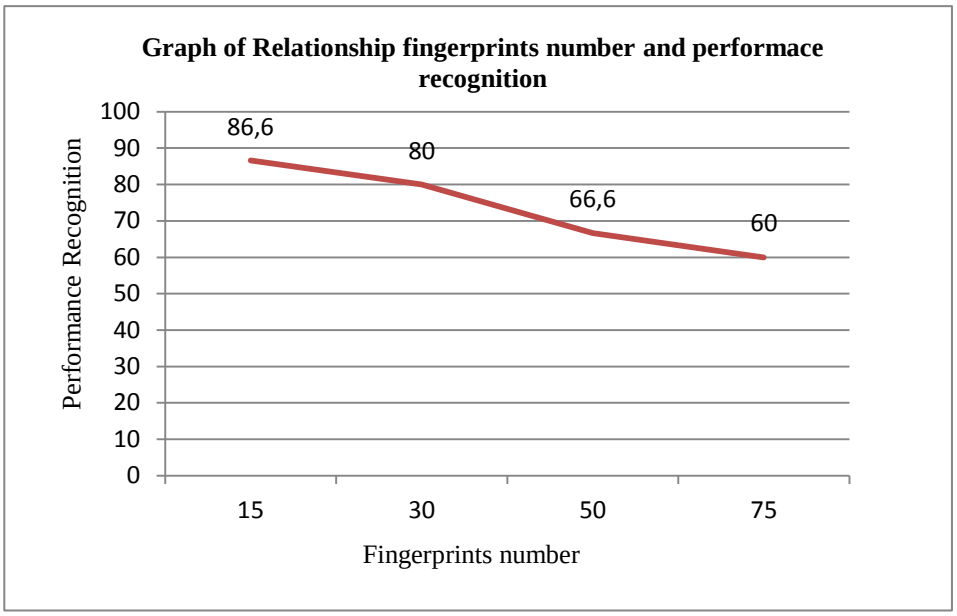


**Figure 8.** Graph of Relationship fingerprints number and performance recognition

From the result of the test in Figure 8, it can be concluded that the more the number of fingerprints inputted, the work of backpropagation artificial neural network performance will decreas. This is related to the more data. Then, the computate will also increas.

The best result of the experiments done loop is with 125 hidden layer, learning rate 0.1, and the data input for 15 data fingerprints. The result of experiment proves that the successful performance of recognition is 86.6% and the percentage of failure is 13.3%.

## 4. REFERENCE

[1] Ravi, J., Raja, K.B. and Venugopal, K.R., 2010, *Fingerprint Recognition Using Minutia Score Matching*, informal publication.
[2] Mc Andrew. A, 2004. *Introduction to C Digital Image Processing with Matlab*, Thomson Course Technology.
[3] LM. Fu, *Neural Networks in Computer Intelligence*, McGraw Hill 1994.
[4] Rashid, M.M and A.K.M.A. Hossain, 2006, *Fingerprint Verification System Using Artificial Neural Network*, Information Technology Journal 5 (6):1063-1067, 2006
[5] Misiti, M., Misiti, Y., Oppenheim, G., Poggi, JM., 1997, *Wavelet Toolbox For Use with Matlab*, The Math Works, Inc
[6] Freeman, J.A. and D.M. Skapura, 1991, *Neural Networks*, pp:89-124, Addison-Wesley Inc, California,
[7] Hirose A, 2003.*Complex Valued Neural Networks*, Academic Press
[8] Kanata, Bulkis, 2008, *Deteksi Sidik Jari Berbasis Alihragam Gelombang-Singkat (Wavelet) dan Jaringan Syaraf Tiruan (JST) Khusus Kota Mataram dan Sekitarnya*, electrical engineering, Faculty Technic, Mataram University, Vol. 7 No. 1 January - Juni 2008. Chapter. 6-11.