DETECTION SYSTEM OF TEN FINGERPRINT PATTERN USING MATHEMATICAL MORPHOLOGY AND BACKPROPGATION ARTIFICIAL NEURAL NETWORK

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Abstract— This research has the aim to produce for detection system of human ten fingerprint patterns that according to Dermatoglyphic. The fingerprint patterns can use for advanced analysis of biological and psychological characteristics. This research uses the backpropagation algorithm of neural networks to identify fingerprint patterns. Initial processing is used the mathematical morphology method before it is detected. The image is changed to a digital image and then it is processed by dilation and erosion for enhancement image. The image that as neuron input of backpropagation is changed to grayscale and 8 x 8 of size. The training process uses 2000 epochs and patterns [200 2 1]. The output results are the identification of human ten fingerprint patterns. This research produce identification is whorl, arch, right loop, and left loop patterns of fingerprints. The result of the research are whorl patterns 51.67%, right loop patterns 23.33%, and left loop 18.33%. The accuracy of the detection system is 93.33%.

Keywords: fingerprint patterns, mathematical morphology, artificial neural network

Abstrak— *Penelitian ini bertujuan untuk menghasilkan sistem deteksi pola sepuluh sidik jari manusia yang berbasis Dermatoglyphic. Pola sidik jari dapat digunakan untuk analisis llanjut karakteristik biologis dan psikologis seseorang. Penelitian ini menggunakan algoritma backpropagation jaringan saraf tiruan untuk mengidentifikasi pola sidik jari. Pengolahan awal menggunakan metode mathematical morphology. Citra diubah menjadi citra digital kemudian diproses dengan dilasi dan erosi untuk perbaikan citra. Citra yang menjadi input neuron backpropagation diubah menjadi grayscale dengan ukuran 8 x 8. Proses pelatihan menggunakan 2000 periode dan pola [200 2 1]. Hasil keluaran berupa identifikasi sepuluh pola sidik jari manusia. Penelitian ini menghasilkan identifikasi pola sidik jari whorl, arch, right loop dan left loop. Hasil penelitian diperoleh pola lingkaran kiri 51.67%, pola lingkar kanan 23.33%, dan pola lingkar kiri 18.33%. Akurasi sistem deteksi adalah 93,33%.*

Kata Kunci: *pola sidik jari, mathematical morphology, jaringan syaraf tiruan*

INTRODUCTION

The science of fingerprints (Dermatoglyphic) has developed hundreds of years ago. The application of scientific disciplines is quite extensive such as in the military (war), police (crime, detective, and intelligence), companies/agencies (recruitment), and also applied to marketing, sports, arts, and other fields. Biometric security systems play an important role in security systems [1], [2], [3]. The researchers found that fingerprints have a genetic code that can naturally be associated with brain cells and intelligence or personality. A fingerprint test is an analysis technique that identifies patterns of personal fingerprint line pattern that are genetically permanently attached to someone. Each pattern is a marker of personal potential and innate characteristics [4], [5], [6]. Morphology deals with the shape and structure of an object. Morphology in digital images can be interpreted as a way to describe or analyze the shape of a digital object. For the description and analysis of digital objects, a tool is needed, called mathematical morphology [7], [8], [9].

The studies related to fingerprint identification are quite numerous. Measuring of image textures

fingerprints using ridgelet energy signature and ridgelet cooccurrence signature. The results of detection and analysis of fingerprints were classified using: artificial neural networks, support vector machine, and k-nearest neighbor [10], [11], [12], [13]. The fingerprint identification used two transform methods in recognition [2]. The fingerprint identification studies using two methods namely DCT (Discrete Cosine transform) and FDCvT (Fast Digital Curvelet Transforms). Initially, a fingerprint image of the sample is detected and used as a reference for further testing [14].

A new fingerprint pattern will be identified referring to the fingerprint pattern that has been identified. The results showed that fingerprint identification with an Artificial neural network resulted in a better identification [12], [13]. An intelligent face feature generation system from Fingerprint. The fingerprint identification sought a relationship between face detection and fingerprinting. Artificial neural networks were used. The results achieved by identifying fingerprints that were tested can be shown, [14],[15], [16].

Most studies on fingerprint identification using artificial intelligence measure the performance of the algorithm and only one fingerprint is used as an image object. The identification of the 10 fingers of a human hand is still not widely used and is a research opportunity. The ten human fingerprint patterns are very important for current biometric databases, such as personal identification, data security, and advanced analysis of biological and psychological characteristics. This study aims to develop a model for the identification of 10 human fingerprint patterns using mathematical morphology (dilation and erosion) and backpropagation neural networks. Hopefully, this research will produce the model of ten fingerprint pattern identification that is cheap, effective, and easy to use.

MATERIALS AND METHODS

Studi ini akan membuat model identifikasi 10 pola sidik jari seseorang menggunakan mathematical morphology dengan proses dilasi dan erosi image data processing dilanjutkan dengan proses identifikasi dan klasifikasi menggunakan jaringan syaraf tiruan backpropagation. Image of ten fingerprint patterns will be processed by image processing followed by mathematical morphology method. Furthermore, fingerprint patterns will be identified by the backpropafation algorithm.

Mathematical Morphology

Mathematical morphology is a tool for extracting image components that are useful in the representation and description of regional shapes, such as boundaries, skeletons, and convex hull [7], [9],[17]. Mathematical morphology can be applied as a first or final step in the process of analyzing digital images for binary images and can be expanded to grayscale images. However, generally mathematical morphology is usually applied to binary images [1], [7], [9].

A digital image can be seen as a 2D amplitude function with discrete coordinates. In mathematical morphology, a digital image is expressed as a set of discrete coordinates [8], [17],[18]. In this case, the set corresponds to the point or pixel of an object in a digital image. objects are considered as a set, then mathematical-mathematical sets such as union, intersection, complement, etc. can be used.

Dilation is used to expand objects in an image [7],[17]. Dilation A with B is stated as follows:

$$D(A, B) = A\ B = \{x: Bx\ A\} \quad (1)$$

A similar process is continued by moving (translating) SE pixel by pixel in the input image Figure 2. Figure 1 below shows an image before and after the dilation process using 3x3 SE with each element having a value of 1.

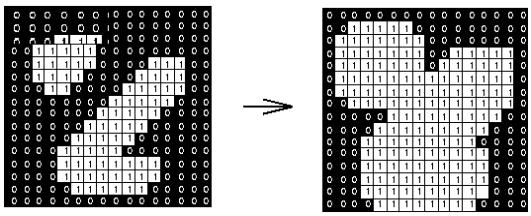

Figure 1. Dilation Using SE 3x3

The erosion process is different from the dilation process. If the dilation produces a wider object, then the erosion process will produce a smaller object [7],[8],[17]. Figure 3 below shows the picture before and after the erosion process with SE measuring 3x3 with all SE elements valued 1.

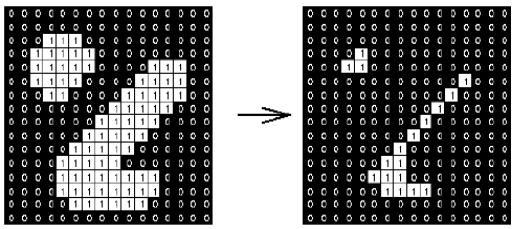

Figure 2. Erosion Using SE 3x3

An opening operation is an operation on Mathematica Morphology which is a joint

operation starting with erosion first followed by dilation. Opening formulation as follows:

$$f \circ s = (f \ominus s) \oplus s \quad (2)$$

A closing operation is a joint operation that begins with dilation followed by erosion.

$$f \blacksquare s = (f \oplus s) \ominus s \quad (3)$$

Backpropagation Algorithm

Back Propagation algorithms were first formulated by Werbos and popularized by Rumelhart and McClelland. This algorithm uses the Supervised Learning learning method [5], [6], [14]. This algorithm is said to be Back Propagation because when a network is given an input pattern as a training pattern, the pattern goes to units at the output layer. Then the output layer units provide a response called network output. When the network output is not the same as the expected output, the output will spread backward in the hidden layer forwarded to the unit in the input layer [13],[14], [19]. Figure 3 shows the backpropagation artificial neural network architecture consisting of the input layer (x), hidden layer (z), and output layer (y).

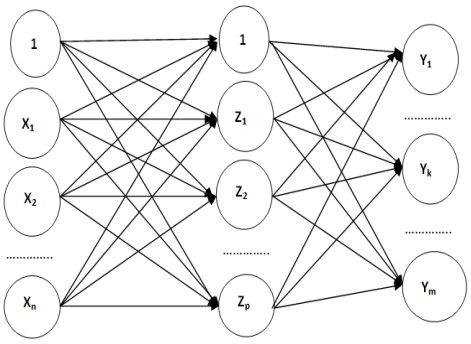

Figure 3. Back Propagation Network Architecture

Fingerprint

Fingerprints are unique and will not change for life unless a wound is severe on the finger [4], [10]. Fingerprints are personal identities that no one can match. If there are 6 billion people in this world, then there are 6 billion fingerprints, not yet found someone who has the same fingerprint as the others. Because of its uniqueness, fingerprints are used by the police in investigating a criminal case (forensic). So in the event of a crime, the crime scene will be cleared up and it is forbidden for anyone to enter because it is feared that it will damage the fingerprints of criminals who may be left behind in the evidence at the scene [13], [15].

Fingerprint patterns can be divided into two types of lines, namely ridge, and valley. Ridge is a dark-colored line, while the valley is an area between bright ridges. There are three types of fingerprints namely Whorl, Loop, and Arch. The properties or characteristics possessed by fingerprints are perennial nature, namely strokes on fingerprints that are attached to humans for life, immutability which means that a person's fingerprints will never change except a condition that is a serious accident that changes the existing fingerprint pattern and individuality which means the unique fingerprint is the owner's originality which cannot be the same as anyone on this earth even in an identical twin [3], [13], [14], [15].

Research Methods

The research method used is the experimental research method, with the following stages of research:

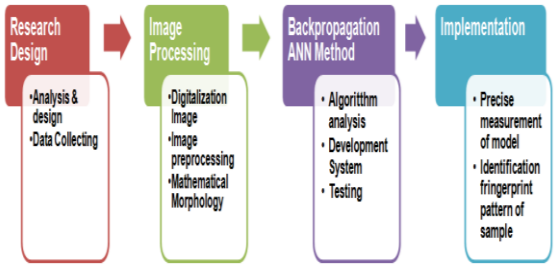

Figure 3. Research Stages

Fingerprint image taking is done manually in this study. The tools and materials used are ink, ink pads, and paper. The image of ten fingerprints is taken by attaching a finger to the pad that has been inked. Then the ten fingers are stamped on the paper one by one. Taking fingerprints is repeated to get a good image and the pattern is clear.

The fingerprint produced by tasting the finger onto the paper is an analog image. For images to be processed further with computation the image is converted to a digital image (image digitization). The analog fingerprint image is converted into a digital fingerprint image by scanning.

The next step is to improve the digital image of the fingerprint and cut it per finger so that the fingerprint image of the finger, index finger, middle finger, ring finger, and little finger is obtained. Initial processing using image processing software and the results are in the format .jpg.

At this stage identify all the requirements for the development of applications of the Fingerprint Detection System. Needs in this system include the needs of hardware and software, the need for fingerprint database in the form of digital images, functional requirements, and performance of the system. navigation structure and user interface design (Graphical User interface).

At this stage, the system is built in both graphical user interface and program (coding). The

development of the system using Matlab 7.01 and GUI software uses the Matlab GUI. The creation of a fingerprint detection system uses the Matlab GUI. For visual files the extension is .fig and for scripts ending in .m. Testing of fingerprint detection systems is carried out with the method of black-box testing and white box testing. It is an activity to test data samples through simulations of the prototypes built, then discuss and analyze the performance of the test results.

RESULT AND DISCUSSION

The image processing process carried out was mathematical morphology by combining both methods (dilation and erosion). At first, the fingerprint image is processed with dilation and the results are processed by the erosion method. Examples of the results of the mathematical morphology processed from fingerprint image samples are as in table 1 below.

Table 1. Results of Fingerprint Processing with Mathematical Morphology

No	Original image	Image of Mathematical Morphology Results
1		
2		
3		
4		
5		
6		

In the process of detecting the ten fingerprint patterns, the fingerprint image is still modified in size. At first, the image is converted to a 160 x 160 matrix by cropping. Next, it is changed to an 8 x 8 matrix size. This process aims to make input images that can be used as input neurons in the Backpropagation algorithm. The fingerprint image that has been changed in size, as shown in the figure:

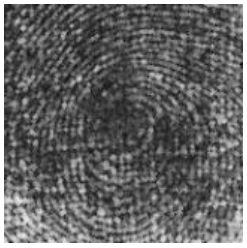

Figure 2. Resize 160 x160 fingerprint image

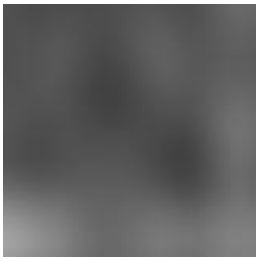

Figure 3. Resize 8 x 8 fingerprint image

The fingerprint image that has been changed to size 8 x 8 is used as the input neuron for the Back Propagation algorithm. In this process 8 x 8 fingerprint image is changed to grayscale, then the matrix element values are used as input neurons.

The initial process was a network training process. In this research 12 inputs are used, namely, 3 Whorl patterned images, 3 Arch patterned images, 3 Right Loop patterned images and 3 Left Loop patterned images. The target in this training is vector: [1 1 1 2 2 2 3 3 3 4 4 4]. Epochs or iterations were chosen in 2000 because the network has converged. Figure 4 shows the flow chart of the backpropagation algorithm used in this study.

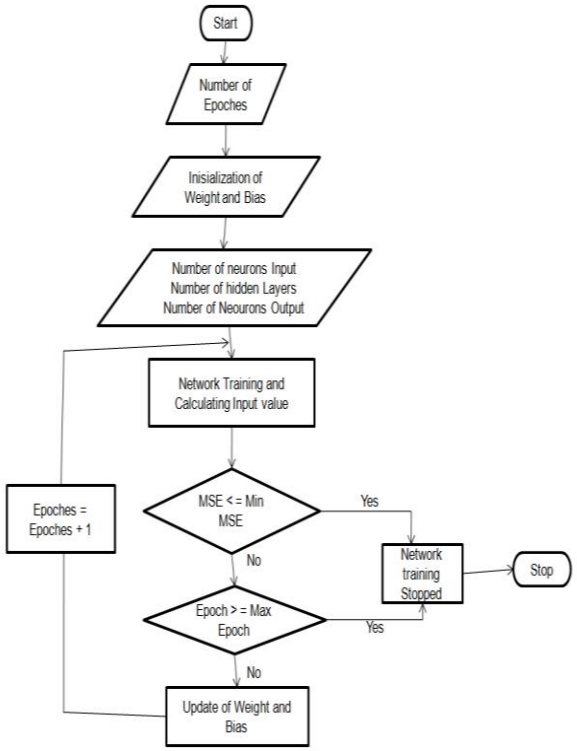

Figure 4. Back Propagation Flow Chart

The identification processed with the artificial neural network backpropagation algorithm was carried out with a certain number of iterations or epochs to get a convergence value or a fixed value so that the identification process always produces the same value. Epoch values above 1000 have converged, as shown in Figure 5 below.

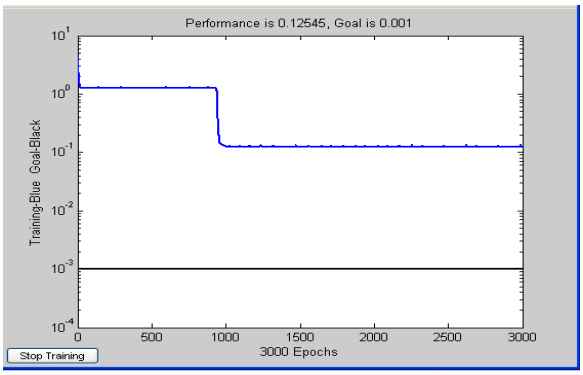

Figure 5 Convergence of Epochs

The results of the detection of the ten fingerprint patterns are a continuation of the testing process to identify fingerprint image patterns. The process of fingerprint pattern detection used the Artificial Neural Network Back Propagation algorithm. In this study training for 2000 epochs, 12 input neurons, 200 first layer neurons, 2-second layer neurons, and one input neuron. The selection of algorithm parameters adjusts to the results of the training process. Table 2 shows the comparison of the performance of the backpropagation pattern for the fingerprint image training process.

Table 2 Comparison of Training Results

No	Back Propagation algorithm pattern	Result of Training
1	Pattern : [50 2 1]	1 1.50 2 1.50 3 1.50 4 1.50 5 1.50 6 1.50 7 3.00 8 3.00 9 3.00 10 4.00 11 4.00 12 4.00
2	Pattern : [100 2 1]	1 1.05 2 1.05 3 1.05 4 1.97 5 1.97 6 1.97 7 3.01 8 3.01 9 3.01 10 3.97 11 3.97 12 3.97
3	Pattern : [200 2 1]	1 1.05 2 1.05 3 1.05 4 2.00 5 2.00 6 2.00 7 3.00 8 3.00 9 3.00 10 3.96 11 3.96 12 3.96

From table 2. above it can be seen that the pattern [200 2 1] produces the training output that is closest to the target [1 1 1 2 2 2 3 3 3 4 4 4].

Before being used for fingerprint pattern detection, a precise model measurement is used to identify the known fingerprint. This precise model measurement used 16 known fingerprint images. From the results of precise testing, there were 13 correct detections and 3. false detection. So the precise model value is:

$$Precise = \frac{True\ Positive\ (TP)}{True\ positive\ (TP) + False\ Positive(FP)} x100\%$$

$$Precise = \frac{12}{12+4} x100\% = \frac{12}{16} x100\% = 75\%$$

The application of this model for fingerprint pattern detection used 240 fingerprint images taken from 24 individual fingerprints. The results of the identification process are shown in Table 3 below.

Table 3 Distribution of Fingerprint Patterns

No	Fingerprint Pattern	Number	Presentation	Note
1	Whorl	124	51,67%	The most common patterns in the sample
2	Right Loop	56	23,33%	
3	Left Loop	44	18,33%	
4	Arch	0	0	There is no sample patterned arch
5	Not Detected	16	6,67%	
	Total	**120**	**100%**	

From table 3 above, it can be seen that the most whorl pattern is around 51.6%, while the arch pattern is absent and 16 images are not detected. The accuracy of the detection system is 93.33%. These results are certainly not optimistic because many factors affect such as data collecting and processing and identification model.

CONCLUSION

The image is changed to a digital image and then it is processed by dilation and erosion for enhancement image. The image that as neuron input of backpropagation is changed to grayscale and 8 x 8 of size. The training process uses 2000 epochs and patterns [200 2 1]. The output results are the identification of human ten fingerprint patterns. This research produce identification is whorl, arch, right loop, and left loop patterns of fingerprints. The result of the research are whorl patterns 51.67%, right loop patterns 23.33%, and left loop 18.33%. The accuracy of the detection system is 93.33%.

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