Palmprint Recognition System Based on Principle-lines Feature Using Euclidean Distance and Neural Network

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***Abstract*— Human recognition system can be done based on the characteristics of palmprint. The palmprint identification system is the palmprint matching process tested with the entire palmprints have been registered on the database. The result is to recognize one individual palmprint. This system consists of software completed with a webcam as input to generate input images. In the system, feature extraction uses detection of the principal-line features and then the image is divided into blocks and form a feature vector of palmprint. The process of feature extraction starts with the palmprint lines acquisition which plays an important role towards the success of recognition. The system developed was tested using 90 palmprint images from 30 individual persons with three samples of palmprint were acquired from one person. Two of three palmprint samples were used as test images, while the rest is used as the reference image. From the test results using Euclidean Distance as its similarity measure, it can be concluded that the recognition system based on principal lines feature of palmprint is well-performed with the successful recognition of the palms tested reaches 100%, both for testing using palm images which have been trained as well as for testing using outer images. While, for recognition using neural network, the results are: The test results show that the performance of palmprint recognizing system with 3 positions of test images provides success rate 88.88 %. The test with straight vertical position provides success rate 90 %. The test with 90° angle to the right position provides success rate 93.33 %. The test with 90° angle to the left position provides success rate 90 %.**

***Keywords* — palmprint recognition; principle-lines feature; overlapping block method; Euclidean distance; Neural Network.**

I. Introduction

Conventional identification techniques to recognize the personal identity using identity card are assumed that they cannot be implemented reliably. It happens because of possibilities of loosing cards or cards used by unauthorized persons. Implementation of conventional identification techniques has been increasingly replaced by biometric identification techniques. Biometrics systems are based on human natural characteristics, i.e. physiological as well as behavioral characteristics, e.g. face, fingerprint, voice, palmprint, iris, retina, DNA, and fingerprint [1].

Based on the above reason, the author would like to develop a recognition system based on the characteristics of human nature, i.e. palms. This system consists of software with a webcam as an input device to generate the input image.

The objectives of research are both to design and to implement the recognition system based on the characteristics of the principal-lines of the palm using the web camera as an image catcher with a computer set as a data processing device and to display the results.

In order that the research can achieve its goals and objectives, then the problem is limited as follows. (1) The system developed is an identification system which uses a peg and a webcam as an acquisition device to produce input images; (2) The method to extract the palmprint feature uses overlapping block method operation; (3) The type of webcam used in the reasearch is web-cam using USB interface; (4) Interface application design uses Borland Delphi 7 with addition of DSPack component.

II. Fundamental Theory

A. Palmprint

Different with fingerprint and face which has long been investigated and used for individual recognition system, palms (palmprint) is a relatively new biometric [4]. Palmprints become very attractive to be developed as biometrics because it has characteristics more than a fingerprint and hand geometry have [5][6]. Surface area of palmprints is wider than the fingerprints expected to produce characteristic that has the ability to distinguish which is more reliable [3].

B. Preprocessing with Cropping Operation

Cropping is an operation to cut out a section of the image so that the image obtained is smaller. The formula used for this operation are [2]:

$$x' = x - x_L \quad \text{for } x = x_L \text{ up to } x_R \qquad (1)$$
$$y' = y - y_T \quad \text{for } y = y_T \text{ up to } y_B \qquad (2)$$

Respectively (x_L, y_T) and (x_R, y_B) are are the coordinates of the points of both the upper left and lower right corners of the image part to be cropped.

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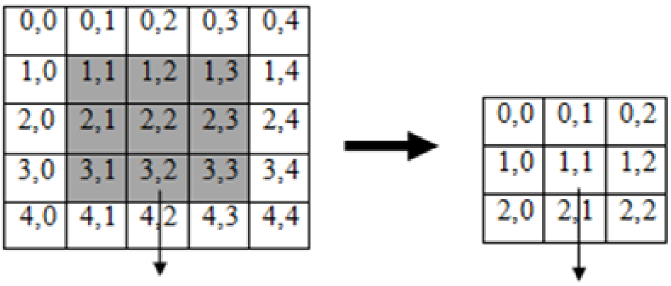

Fig. 1. Upper left and lower right corners of the image part to be cut

Fig. 1 illustrates the process of cropping an mage. At the initial image, the original image pixels size is 5 x 5, then image cropping from initial coordinates (1,1), up to the coordinates of the end (3.3) or with the width and height of each 3 pixels to form a new image of 3 x 3 pixels. The result image after cropped contains pixel values of the coordinates (1,1) to (3,3) in the original image.

C. Feature Extraction

- Line Detection

  Line detection is used to detect lines in an image, i.e. palmprint lines. For detecting the lines, 4 (four) masks are used, as depicted in Fig. 2.

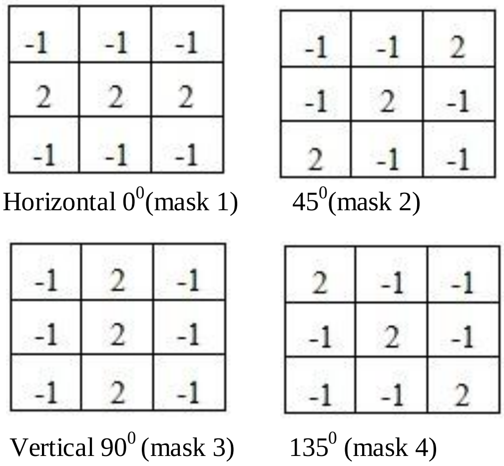

Fig. 2. Masking for 0°, 45°, 90°, 135° directions respectively.

If the first mask is moved around the image it will result in closer lines (the thickness of one pixel) with the horizontal direction. With a background of constant, maximum response will be generated when the line bypassed the center line of the mask. In the same way, a second mask on the image will give the best response to a line that is directed 45°, the third mask for vertical lines and a fourth mask for lines with -45° direction. This direction can also be determined by noting the direction offered by the mask, weighted by coefficients greater than other possible directions [10].

- Block Processing

  There are two (2) types of block division, those are the division of overlapped block and the other is the division of non-overlapped blocks. In the division of overlapped blocks, in one block with adjacent blocks, there are several overlapped pixels [7]. While the division of non-overlapped blocks, the pixels of a block with adjacent blocks are not overlapped. Fig. 3 shows the distribution of block with 4 x 4 sized, both for overlapped blocks as well as non-overlapped blocks, respectively. A gray area in the figure shows an overlapped section.

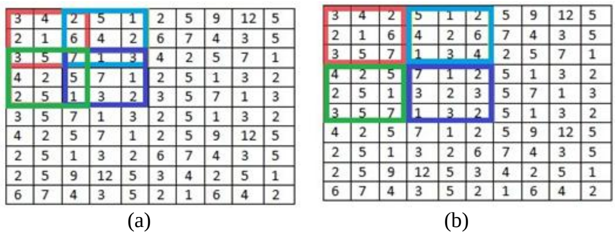

Fig. 3 (a) division of overlapped; (b) division of non-overlapped blocks

The system developed uses overlapped block method. Feature vector of the block is formed by calculating the standard deviation of each block.

D. Similarity Measure using Normalized Euclidean Distance

The results of block operations will generate the feature vector. To measure the similarity between the testing feature vector and training feature vector, we used normalized Euclidean distance for feature vector images. Normalized Euclidean distance equation is stated as follows [9].

$$\bar{d}(u,v) = \sqrt[2]{\sum_i (\bar{u}i - \bar{v}i)} \quad (3)$$

where

$$\bar{u} = \frac{ui}{\|u\|}, \ \bar{v} = \frac{vi}{\|v\|} \quad (4)$$

$\|v\|$ is a norm of v which can be obtained from:

$$\|v\| = \sqrt[2]{\sum_i vi^2} \quad (5)$$

Where u and v are, respectively, feature vector of training images and feature vector of testing images.

The smaller value of $\bar{d}(u,v)$ more similar two feature vectors which are matched. Otherwise, the greater value of $\bar{d}(u,v)$ two feature vectors will be indicated as more different. The property of normalized Euclidean distance are that its value is in interval of $0 \leq \bar{d}(u,v) \leq 2$.

E. Recognition using Backpropagation Neural Network

Backpropagation, an abbreviation for "backward propagation of errors", is a common method of training artificial neural networks used in conjunction with an optimization method such as gradient descent. The method calculates the gradient of a loss function with respect to all the weights in the network. The gradient is fed to the optimization method which in turn uses it to update the weights, in an attempt to minimize the loss function.

Backpropagation requires a known, desired output for each input value in order to calculate the loss function gradient. It is therefore usually considered to be a supervised learning method, although it is also used in some unsupervised networks such as auto encoders. It is a generalization of the delta rule to multi-layered feedforward networks, made possible by using the chain rule to iteratively compute gradients for each layer. Backpropagation requires that the activation function used by the artificial neurons (or "nodes") be differentiable [8].

III. System Design

A. Hardware Design

The hardware of palmprint identification system developed is shown in Fig. 4.

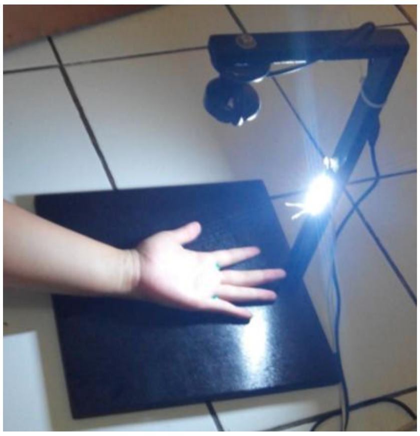

Fig. 4. Hardware of palmprint identification system

The hardware designed to identify the palmprint consists of (a) a web-camera with 5 megapixels resolution, (b) black board and (c) pegs. The distance of web-camera to the black board is 36 cm with pegs conditioned so that the hand cannot change its position. Black board size is 30 x 20 cm.

B. Software Design

The system interface application was created using Delphi 7. The application interface is used to capture images from a web camera, to process images, to save data into database, and to display the results of identification. The database used is Ms Access 2007.

At this identification system, the input required is in the form of user's palm image and the output is the identity of the user. Palmprint identification system consists of two parts, both namely the training and identification parts. Part of training is useful to register the user on the database system and to save the users' palm biometric features. While the identification is useful to compare the characteristics of the user's palm with the features that have been stored in the database.

1) Training process algorithm: The training process is the process of registration (enrollment) the features of the user's palm to the system to build a reference database (reference). The features obtained are from palm image feature extraction process results. Flow diagram of the feature extraction process is shown in Fig. 5. Feature extraction process begins with the image capture process from a web camera, and the image is cropped to take the principle lines of the palm. Furthermore, the image is converted into gray images (grayscale). The palmprint image then will be normalized first before the line detection process and operation blocks. The normalization process is aimed for reducing noise and differences in light intensity during the image acquisition process. Results of the operation process in the form of a matrix of blocks measuring 15 x 15 stored in the database as a reference feature matrix palms.

2) Algorithm of Identification Process: The identification process is the main process in palmprint identification systems. Algorithm of identification process will show how the system performs the identification process, so as to determine the identity of the palms used as the input image. Flowchart of the identification process can be shown in Fig. 6.

IV. System Testing and Results

A. Identification using Euclidean Distance

System testing is done by using 90 images belonging to 30 people. Each person is represented by three sample of palmprint images and two of which are used as the reference image (the image of training), and one remainder is used as test images. Parameters are calculated from this test is the success rate in identifying a palm belonging to one person. The equation for the success rate is:

$$\text{\% success rate} = \frac{\text{number of correct-identified data}}{\text{number of test data}} \times 100\% \qquad (6)$$

Table I shows the results of testing using 30 test images. From the table, it can be shown that the system is able to recognize all of the palmprint images in normal lighting conditions. Based on the above test showed that this system has a performance of 100% success.

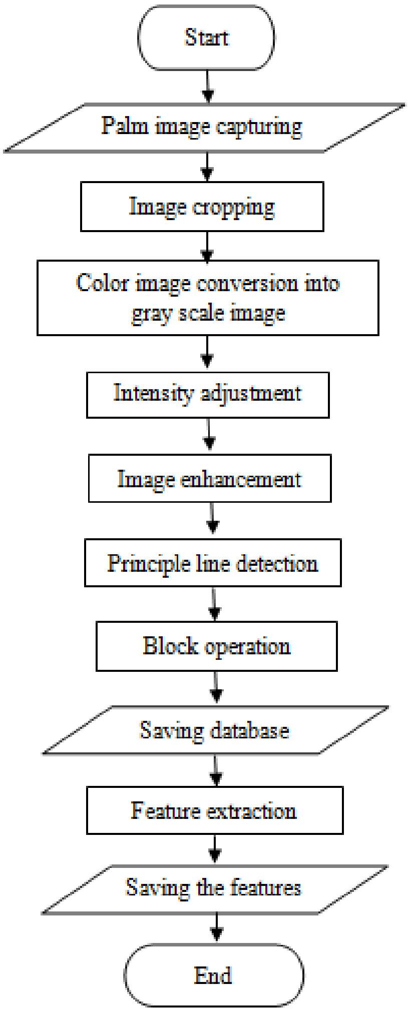

Fig. 5. Flow diagram of feature extraction in training process.

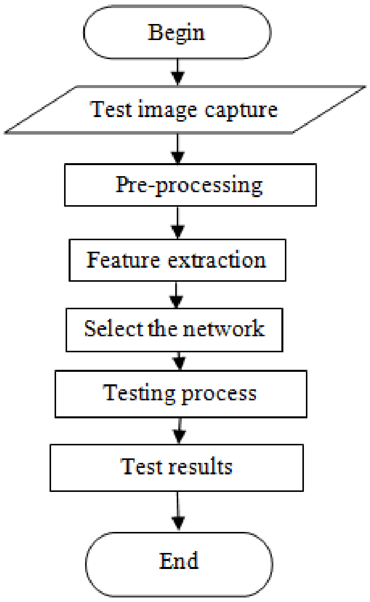

Fig. 6. Flow diagram of identification process

TABLE I RESULTS OF TESTING USING 30 TEST IMAGES.

Image files	Identified as	Euclidean Distance	Identification result
Palm_1	001	0.2041	Correct
Palm_2	003	0.1634	Correct
Palm_3	006	0.1972	Correct
Palm_4	007	0.2381	Correct
Palm_5	009	0.1979	Correct
Palm_6	011	0.2377	Correct
Palm_7	014	0.2444	Correct
Palm_8	016	0.1898	Correct
Palm_9	018	0.2116	Correct
Palm_10	019	0.2423	Correct
Palm_11	021	0.2406	Correct
Palm_12	023	0.3668	Correct
Palm_13	025	0.2075	Correct
Palm_14	028	0.2303	Correct
Palm_15	030	0.2453	Correct
Palm_16	031	0.2110	Correct
Palm_17	034	0.1916	Correct
Palm_18	036	0.1982	Correct
Palm_19	037	0.2354	Correct
Palm_20	039	0.2529	Correct
Palm_21	042	0.2028	Correct
Palm_22	044	0.2323	Correct
Palm_23	045	0.2401	Correct
Palm_24	048	0.2025	Correct
Palm_25	049	0.2282	Correct
Palm_26	052	0.1847	Correct
Palm_27	054	0.1955	Correct
Palm_28	055	0.2117	Correct
Palm_29	057	0.1706	Correct
Palm_30	060	0.1945	Correct

B. External image recognition using Euclidean Distance

In order to perform the tests using external test images that are not included in database, the threshold value is used. Without using a threshold value, the external test image will still be recognized as one of the images in the database since its recognition process using nearest or smallest Euclidean distance.

The threshold value can be obtained by the sum of the mean and standard deviation, the value is 0219 + 0.0366 = 0.2556. This threshold value is then used to test external images. Testing of external test images made with 10 palm images that had not been registered in the database. The test results are shown in Table II.

TABLE II. TESTING OF EXTERNAL TEST IMAGES.

Image files	Recognized as	Euclidean distance	Results
Outter_01	Unidentified	0.3841	Correct
Outter_02	Unidentified	0.3518	Correct
Outter_03	Unidentified	0.3885	Correct
Outter_04	Unidentified	0.3807	Correct
Outter_05	Unidentified	0.3573	Correct
Outter_06	Unidentified	0.3402	Correct
Outter_07	Unidentified	0.4132	Correct
Outter_08	Unidentified	0.3937	Correct
Outter_09	Unidentified	0.3560	Correct
Outter_10	Unidentified	0.3764	Correct

C. *Recognition Test using Backpropagation Neural Network*

In the process of retrieval of image data, 30 respondents invited with each respondent there are 9 (nine) images are captured. The the total data are 270 palm images. The data is divided by 2 (two), there are 180 training image data and 90 test image images. In collecting the data, there are 3 kinds of position, i.e. the normal position, 90° to the right direction, and 90° to the left direction, so that each respondent are taken three times every position, two of which used as training image and the rest used as test image.

Parameters are calculated from this test is the success rate of identification, which is stated in Eq. (6). There are 2 (two) scenarios to test the network performance in the research. Those scenarios are:

1) Network Testing on 3 (three) combination of positions: This test uses a network that is trained directly at the same time for 3 position i.e. upright direction, 90° to the right direction, and 90 ° to the left direction.

2) Network Testing on each position: This test uses each network which has trained for each position, so that in the test, there are 3 (three) networks trained for testing each positon, i.e. upright direction, 90° to the right direction, and 90° to the left direction.

Table III shows the results of 4 (four) types of testing.

TABLE III. TEST RESULTS OF 4 (FOUR) TYPES OF TESTING

Test results			
Combination of 3 (three) position	Upright position	90° to the right direction	90° to the left direction
88,88%	90 %	93.33%	90%

Representation of the test results in bar graph can be shown in Fig. 7.

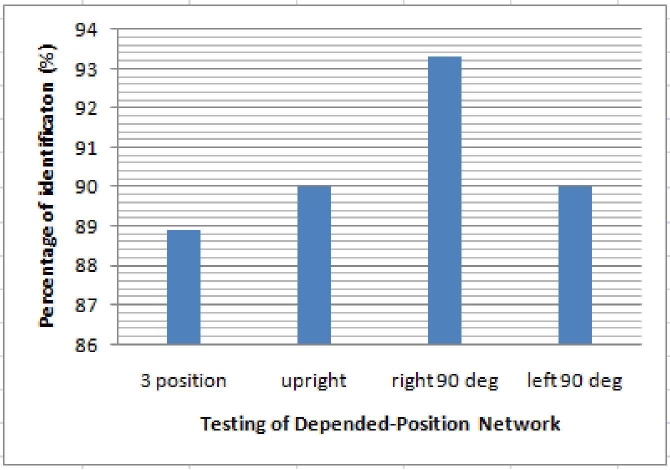

Fig.7. Comparison on success rate of identification from 4 test image data

Based on Fig. 7 which is a comparison of the percentage of success in all four tests, it can be concluded that the test using the trained network on one position of the palm image has the result with higher percentage of success than testing using the trained network in 3 positions at once. This is probably due to the correlation between the three positions used as the data has different variations of 90 degrees, so testing results on network with 3 positions at once are the lowest.

D. *Analysis*

Based on testing using two different scenarios, i.e. recognition using Euclidean distance and using backpropagation neural network, it can be seen that the test using the Euclidean Distance gives better results. The best recognition of the 30 respondents indicated that the Euclidean distance is more capable of recognition, in this case with a success rate of up to 100%. While recognition using back-propagation neural network has the highest recognition rate of 93.33%.

The results show that the similarity measure using Euclidean distance is better to find similarities characteristic of palms. It also means that the characteristics of the palms is quite unique so characteristic differences can be detected by a similarity measure, i.e. the Euclidean distance.

Meanwhile, recognition using backpropagation neural network, although it can be said to have the highest level of recognition is quite good, that is 93.33%, but the results are not as good as the use Euclidean Distance. This is probably caused by the characteristics that are not trained in the neural network has a unique high enough. Therefore, there is some data identified as wrong time in the testing. In contrast to the Euclidean distance, The slightest difference in the characteristic vector can always be recognized. This is caused by the Euclidean distance always produce different number for different features although the difference is very small. Therefore, backpropagation neural network has not been able to recognize the overall test data well when compared to the Euclidean distance.

V. CONCLUSIONS

From the research has been done, it can be obtain some conclusions as follows. Based on the method of overlapping block to extract the palmprint features, it can be seen that the test using the Euclidean Distance gives better results. The best recognition of the 30 respondents indicated that the Euclidean distance is more capable of recognition, in this case with a success rate of up to 100%. While recognition using back-propagation neural network has the highest recognition rate of 93.33%. The results show that the similarity measure using Euclidean distance is better to find similarities characteristic of palms. It also means that the characteristics of the palms is quite unique so characteristic differences can be detected by a similarity measure, i.e. the Euclidean distance.

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