Palmprint Recognition Systems based-on Backpropagation Neural Network and Euclidean Distance using Principal Components Analysis (PCA) Feature Extraction

by R. Rizal Isnanto

Palmprint Recognition Systems based-on Backpropagation Neural Network and Euclidean Distance using Principal Components Analysis (PCA) Feature Extraction

R. Rizal Isnanto[1], Ajub Ajulian Zahra[2], Adrian Khoirul Haq[2] and Fachrul Rozy[2]

[1]Computer Engineering Department, Diponegoro University, Semarang
[2]Electrical Engineering Department, Diponegoro University, Semarang
rizal_isnanto@yahoo.com

Abstract

Palmprint recognition system has been one promising biometric system used in Presence System. There are some methods to recognize the individual palmprint as well as to extract its feature. In this research, two recognition methods are compared, i.e., backpropagation neural network and similarity measure using Euclidean distance. While, for feature extraction, we implemented Principal Components Analysis (PCA) method. From the research, it can be concluded that from test results, the best recognition using backpropogation neural networks is 93.33% which is reached when parameters used are: 100 principal components, 1 hidden layer, and 75 neurons. While, implementation of similarity measure using Euclidean distance, the best recognition rate is 96.67% which is reached when 75 principal components are used. When considering the time consumed in recognition, the Euclidean distance gives the better result, i.e. 17.09 seconds, while using backpropagation neural network with 75 neurons, time consumed is 425 seconds. Therefore, from this research, recognition implementation combining both PCA and Euclidean distance are more suggested rather than using combination of PCA and backpropagation neural network.

Keywords: Palmprint recognition, backpropagation neural network, Euclidean distance, Principal Component Analysis (PCA), feature extraction

1. Introduction

Conventional personal identification techniques identity card are assumed that they cannot be implemented reliably. It happens because of possibilities of cards loss or used by unauthorized persons. Implementation of conventional identification techniques has been increasingly replaced by biometric technique-based identification. Biometrics systems are based on human natural characteristics, *i.e.,* physiological as well as behavioral or chemical characteristics, *e.g.,* face [2], fingerprint, voice, palmprint, iris, retina, DNA, fingerprint or even odor [5]. There are some research concerned in both palmprint identification as well as in palmprint verification system [4].

Considering the above reason, the authors would like to analyze the comparison between recognition systems based on the characteristics of human nature, *i.e.,* palms. There are many algorithms to extract the palmprint features as well as many algorithms to identify or classify the features [1]. In this research, the Principal Components Analysis (PCA) is used to extract the palmprint features. While, the methods to identify the individual features are backpropagation neural networks and similarity measure using Euclidean distance. Both identification methods are then analyzed and compared, for which we can obtain which best identification method based on PCA feature extraction.

In this research, the palmprint recognition system are designed using data from palm images captured by digital camera. The palm images are then processed in some stage to obtain its characterics, until the system can decide who owns the palmprint inputted.

An example of a palm image with its cropping area in black-line box and its result after cropping can be depicted in Figure 1(a) and 1(b), respectively.

(a)   (b)
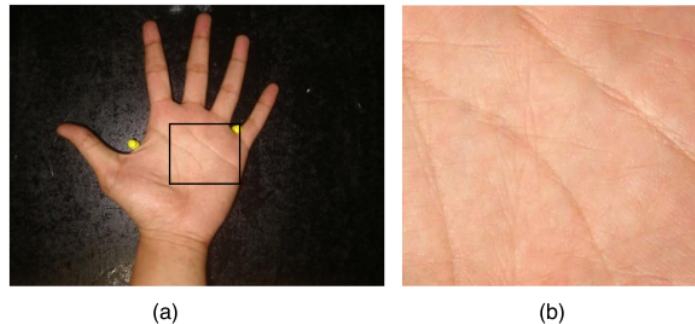
**Figure 1. (a) Palm Image with its Cropping Area in Black-line Box.
(b) Result of Palm Image after Cropping.**

2. Fundamental Theory

There are some algorithms can be implemented to extract the features of palmprint. Some previous research have been done related to palmprint verification system [4], *e.g.,* fractal dimension method and lacunarity [6], palmprint principal lines feature extraction [7]. Other research on palmprint also is done by Badrinath, *et. al.,* which focuses on palmprint recognition system using ID-DCT features [8]. While Iskandar had done a research on palmprint feature extraction using Haar wavelet and Euclidean Distance used as its similarity measure [9]. In this section, some methods used in the research are explained, *i.e.,* Principal Component Analysis (PCA), similarity measure using Euclidean Distance, and backpropagation neural network.

2.1. Principal Component Analysis (PCA

Principal Component Analysis (PCA) is one of valuable algorithm which produced by applied linear algebra. PCA procedure is basically purposed to simplify the observed variables by reducing its dimension. It can be done by removing the correlation between independent variables. The method used is transforming the original independent variables into new variables which are not correlated without removing significant information. These new variables then are called principal components. With this reduction, computation time can be diminished and the unnecessary complexity of palm images can be removed [12]. In PCA, there are some vectors called eigenvector and some values called eigenvalue which enable us to get most significant feature in the dataset [11].

2.2. Similarity Measure using Normalized Euclidean Distance

After passing through feature extraction process and parameter values, in this case we have principal components, are obtained, the next stage is calculating the nearest distance (Euclidean distance) of feature vector value of an image [9]. The closer the Euclidean distance, it is getting closer to a certain image. For example, values of feature vectors of reference image $A_i = \left(A_1, A_2, \ldots\ldots, A_n \right)$ and values of feature vector of

tested image is $B_i = (B_1, B_2, ..., B_n)$, then Euclidean distance between values of feature vectors of reference image and values of feature vector of tested image can be expressed as:

$$D(A,B) = \sqrt{\sum_{i=0}^{n} \frac{(|A_i - B_i|)^2}{A_i}} \qquad (1)$$

where:

$D(A,B)$ = Euclidean distance between palm image A and palm image B

A_i = Feature vector of palm image A

B_i = Feature vector of palm image B

n = vector length (sum of textural features) of vector A and vector B

2.3. Recognition using Backpropagation Neural Network

Backpropagation is an abbreviation for "backward propagation of errors". It 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. Therefore, it is usually considered to be a supervised learning method, although it is also used in some unsupervised networks such as auto encoders. Backpropagation 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].

3. System Design

System design is an important stage in application of a concept, both in program code or in its tools, in order to in its system development, it can works systematically, structured, and organized as well as the system designed. One step in system development is data acquisition using hardware. In data acquisition process, many responders were invited to test the application. The number of responder invited is 30 persons. From each person, 3 (three) image data are captured. Therefore, the total number of image stored in database is 90 image data.

In developing the palmprint recognition system, some supporting tools are needed. Some tools used can be differentiated into 2 (two) main categories, *i.e.,* hardware and software which will be explained here below.

Some hardwares used in this research are: Computer set with the specifications: Prosesor Intel(R) core(TM) i5 with RAM 4 GB, and Microsoft Windows 7 OS; and the capturing 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. Figure 2 shows the capturing hardware used in the research. Whereas the application software used is Matlab R2008a. In Matlab, there are many procedures and functions related to Image Processing, which are compiled in Image Processing Toolbox [3]. For neural network programming, Matlab is also completed with Neural Network Toolbox [10].
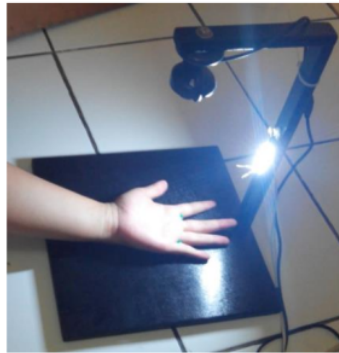
Figure 2. Hardware to Capture Palmprint Images.

3.1. Preprocessing Stage

Preprocessing stage is an initial process of data after extracted, for which it can be processed in next recognition or identification process. It performs to adapt and normalize some parameters required in the next process. Figure 3 depicts the preprocessing flowchart in feature extraction.
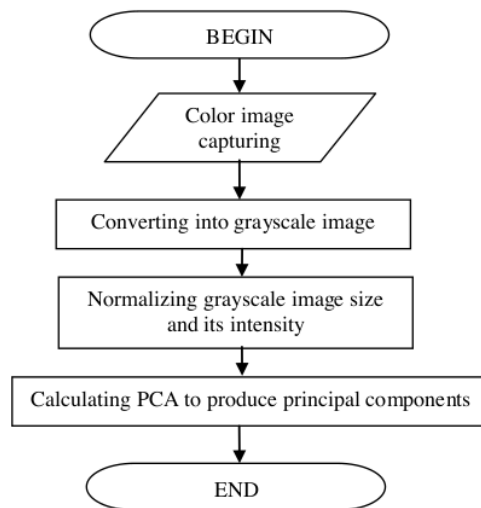

Figure 3. Preprocessing Flowchart.

3.2. Training Process

Considering that in this research we use two different process in identification, *i.e.,* using Euclidean distance and backpropagation neural network, we used two different scheme. When we implement Euclidean distance, there is no training process. The process is only calculating similarity measure using Equation (1). Whereas, when we implement backpropagation neural network, both training as well as identification

processes are performed. The training process in neural network is the process to get both weight and bias values from each database. In the training, database values as input vector are required and trained on target obtained. Figure 4 shows an example of architecture of artificial neural network.
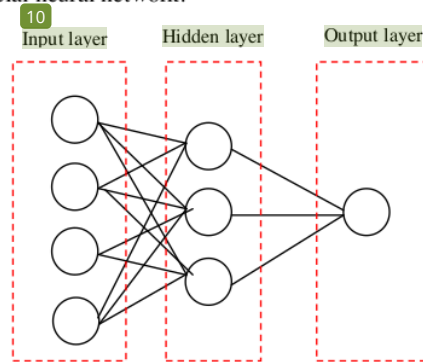
Figure 4. An Example of Architecture of Artificial Neural Network.

4. Results and Discussion

An example of implemented research interface is implementation of presence system using palmprint recognition which is depicted in Figure 5. The identification method used for this example is combining PCA and Euclidean Distance. The system is implemented as a prototype in Electrical Engineering Department of Diponegoro University using Bahasa Indonesia (Indonesian language) instead of English, because all users of the system are most familiar with Bahasa Indonesia.
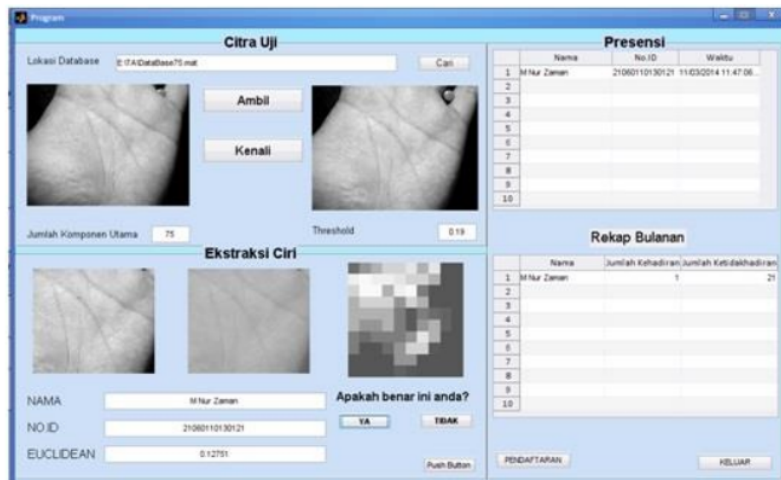
Figure 5. An Example of Implemented Research Interface.

In tests stage, we divided the test into two main subtests. First, identification based-on similarity measure using Euclidean distance (PCA + ED), and the other is identification based-on classification method using backpropagation neural network (PCA + BNN). In both tests we use recognition percentage measure to obtain the best method.

$$\text{Recognition Percentage} = \frac{\text{number of 'true' recognized tests}}{\text{total number of tests}} \times 100\% \qquad (2)$$

4.1. Recognition Test using Euclidean Distance

From 30 test data used, we evaluated on the effect of number of principal component on recognition percentage. Data test here are purposed to analyze the effect of number of principal components usage. Besides that, from this test we can define what optimal number which can give the best recognition percentage.

Recognition results with varying the number of principal components can be depicted in Table 1.

Table 1. Test Results on Effect of Number of Principal Components against its Recognition

No	Number of principal components	Training time (second)	Percentage of recognition tests
1	50	16.75	95%
2	75	17.09	96.67%
3	100	17.37	95%
Average		17.07	96.11%

From Table 1, it can be concluded that the best recognition percentage, *i.e.,* 96.67% occurs when 75 principal components are used. While 50 components are used, the training time was shortest, *i.e.,* 16.75s. However, when we will consider both the optimal number of principal components as well as the training time, from this table, it is indicated that there is no significant difference in term of training time. Therefore, in recognition test using Euclidean distance, the optimal number of principal components is occurred when 75 components are applied.

4.1. Recognition Test using Backpropagation Network

The purpose of the recognition test using backpropagation network is to analyze the effect of principal components number usage against its recognition rate. Besides that, from this test it can be known what optimal number of principal components which gives the best recognition rate. Table 2 depicts the results of the effect of principal components against its recognition rate.

Table 2. Test Results of Principal Components' Effects

No	Number of principal components	Training time (seconds)	Recognition results	
			Training images	Testing images
1	100	425	100%	93.3%
2	50	299	100%	86.7%
3	25	229	100%	83.3%
4	10	135	91.7%	66.7%

The usage of the principal components provides different levels of recognition. On the use of 100 components, it provides the recognition rate of 93.3% with the learning times 425 seconds. On the use of 50 components provides the recognition rate of 86.7% and takes 299 seconds, while the use of 25 components resulted in the recognition rate of 83.3% with 229 seconds of learning time, and the use of 10 components resulted in 66.7% recognition rate and requires a learning time 135 seconds.

The use of principal components greatly influences the recognition rate. The use of 100 principal components will result the best recognition rate, *i.e.,* 93.3%, and the worst recognition occurs on use of 10 components with the recognition rate of 66.7%. However, the use of 50 principal components gives a pretty good recognition rate, *i.e.,* 86.7% with a shorter learning time than the use of 100 components. This shows that the number of major components used highly influence the success rate of recognition as well as the training time is getting shorter by the less number of principal components.

4.2.1. Testing on the Effect of Hidden Layer Number

The purpose of testing on the effect of hidden layer number is to analyze the effect of changes in the number of hidden layer against its recognition percentage. In addition, from this test, it will be known the optimal number of hidden layer which can be used on artificial neural network that has been developed. Test results on the effect of hidden layer number against its recognition rate can be depicted in Table 3.

Table 3. Test Results of Hidden Layer Number

No	Number of hidden layer	Learning time (seconds)	Recognition results	
			Training images	Test images
1	1 layer	425	100%	93,3%
2	2 layer	646	100%	90%
3	3 layer	2349	100%	70%

The use of hidden layer number on artificial neural networks will provide different levels of recognition. On the use of one hidden layer provides a level of recognition 93.3% with learning time takes 425 seconds. While the use of 2 (two) hidden layers provides a recognition percentage 90% and takes 646 seconds, and the use of 3 (three) hidden layers 3 provides the recognition rate of 70% and learning time takes 2,349 seconds.

Neural network with the best recognition rate is obtained by the number of hidden layer = 1 (93.33%) with 425 seconds of training time. It means that the most optimal network according the results of experiments built with one hidden layer. But this is not fixed conclusion because artificial neural networks have properties that can be vary. As well as training time is directly proportional to the number of hidden layer is used, the more hidden layers the longer the number of training required.

4.2.2. Test on the Effect of Neuron Number

The purpose of this test is to analyze the effect of neuron number usage against its recognition percentage. In addition, from this test it can be known what optimal number of neuron which gives the best recognition rate. Table 4 shows the results of the test.

Table 4. Test Results of Number of Neuron

No	Number of neuron	Training time (seconds)	Recognition results	
			Training images	Testing images
1	75	425	100%	93.33%
2	60	416	100%	90%
3	45	388	70%	63.33%

In using 75 neurons, it provides the best recognition rate, *i.e.,* 93.33% which takes 425 seconds for training time. While using 60 neurons, it provides the recognition percentage 90% which takes 416 seconds for training time. In the third test, 45 neurons are applied, with the results are that the recognition rate is 63.33% which consumes 388 seconds for training time.

From this test, it can be concluded that number of neurons will influence on the recognition rate. Also, the training time will tend to be shorter when using less number of neurons.

After we have some results both based on similarity measure using Euclidean Distance as well as the implementation of backpropagation neural network, we can conclude combination of PCA and Euclidean distance will gives better performance, *i.e.,* 96.67% that combination of PCA and backpropagation neural network results in, *i.e.,* 93.33%. This comparison results on both combinations of feature extraction and its recognition rate can be depicted in Figure 6.
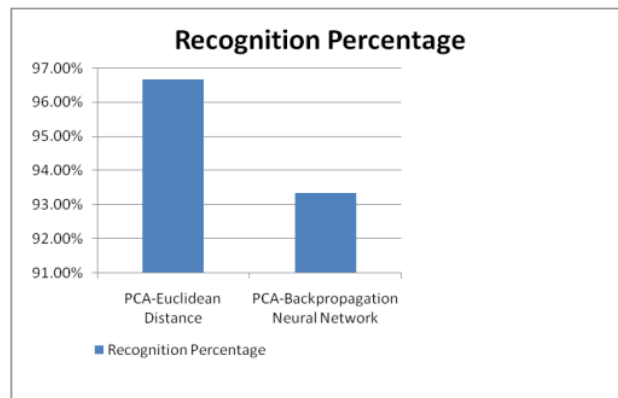
Figure 6. Recognition Percentage Comparison.

From Figure 6, it can be explained that the recognition implementation combining both PCA and Euclidean distance is more suggested rather than using combination of PCA and backpropagation neural network. However, its difference between both combination is slice enough for which we can do more in depth research to obtain the more exact which combination will provide the best recognition as well as we can select other feature extraction methods, *e.g.,* wavelets, moment invariants, and gray level co-occurrence matrix (GLCM) with identification or classification methods vary, *e.g.,* Minkowski distance, Dynamic Time Warping (DTW) and linear vector quantization (LVQ) neural network.

We also have provided comparison between two proposed scheme with three earlier algorithms, *i.e.,* DCT-based local feature extraction algorithm [13], multispectral palmprint recognition using a hybrid feature [14], and Gabor-based features in color palmprint images [15]. Table 4 shows the comparison of these 5 (five)

algorithms. As we can notice, two proposed algorithms produce good recognition rate but are not the best when compared with previous 3 (three) algorithms. The amount of specimen of palmprint which is implemented in this research is very limited, so that it is suspected to be the cause of the success rate to be "not satisfactory" when compared with other algorithms.

Table 4. Comparison Results with other Palmprint Recognition Algorithms

Methods	Recognition Rate
PCA + ED	96.67%
PCA + BNN	93.37%
DCT + ED [13]	99.97%
Hybrid feature [14]	98.88%
Gabor + PCA + ED [15]	98.71%

In the next research, as future work, we will do research using more specimens from more respondents or using large palms database which are available online, *i.e.,* from PolyU database [16]. The limited amount of palms specimen is suspected to be the cause of the success rate is not satisfactory compared with other algorithms which are reported by other 3 (three) previous research. The use of more number of palmprint samples both for training as well as for testing are expected to produce the more trustworthy recognition rate.

5. Conclusions

From the research has been done, it can be obtain some conclusions as follows. In this research, two recognition methods were compared, *i.e.,* backpropagation neural network and similarity measure using Euclidean distance. From the research, it can be concluded that from test results, implementation of similarity measure using Euclidean distance provides the best recognition rate, *i.e.,* 96.67% which is reached when 75 principal components are used. When considering the time consumed in recognition, the Euclidean distance gives the better result, *i.e.,* 17.09 seconds. While using backpropagation neural network with 75 neurons, time consumed is 425 seconds, and the best recognition using backpropagation neural networks is 93.33% which is reached when parameters used are: 100 principal components, 1 hidden layer, and 75 neurons. Therefore, from this research, recognition implementation combining both PCA and Euclidean distance is more suggested rather than using combination of PCA and backpropagation neural network.

Acknowledgments

References

[1]   Kumar, D. C. M. Won., H. C. Shen and A. K. Jain, "Personal Verification Using Palmprint and Hand Geometry Biometric", Proceedings of *AVBPA*, Guildford, UK, **(2003)** June, pp. 668–678.

[2]   A. Mabruk, "Face Recognition Using the Method of Adjacent Pixel Intensity Difference Quantization Histogram Generation", Institut Teknologi Sepuluh, Surabaya, **(2010)** November.

[3]   A. McAndrew, "An Introduction to Digital Image Processing with Matlab", School of Computer Science and Mathematics Victoria University of Technology, Vicoria, Australia, **(2004)**.

[4] D. B. L. Bong, R. N. Tingang and A. Joseph, "Palm Print Verification System", Proceedings of the World Congress on Engineering, London, U. K., vol. I, **(2010)**.

[5] D. Putra, "Sistem Biometika", Penerbit Andi, Yogyakarta, **(2009)**.

[6] D. Putra, "Sistem Verifikasi Biometrika Telapak Tangan dengan Metode Dimensi Fraktal dan Lacunarity", Universitas Udayana, Denpasar, **(2009)**.

[7] D. Putra, "Sistem Verifikasi Menggunakan Garis-Garis Telapak Tangan, Universitas Udayana", Denpasar, **(2007)**.

[8] G. S. Badrinath, K. Tiwari and P. Gupta, "An Efficient Palmprint Based Recognition System Using 1D-DCT Features", Proceedings of Intelligent Computing Technology: 8th International Conference, ICIC, **(2012)**.

[9] I. K. Iskandar, "Ekstraksi Ciri Citra Telapak Tangan Dengan Alihragam Gelombang Singkat Haar Menggunakan Pengenalan Jarak Euclidean", Teknik Elektro Universitas Diponegoro, Semarang, **(2014)**.

[10] J. S. Jong, "Jaringan Syaraf Tiruan dan Pemrogramannya Menggunakan Matlab", Andi Offset, Yogyakarta, **(2005)**.

[11] R. S. Putra, "Perancangan Aplikasi Absensi dengan Deteksi Wajah Menggunakan Metode Eigenface", STMIK Budi Darma, Medan, **(2013)**.

[12] Soemartini, "Principal Component Analysis (PCA) sebagai Salah Satu Metode untuk Mengatasi Masalah Multikolinearitas", Universitas Padjajaran, **(2008)**.

[13] H. Imtiaz and S. A. Fattah, "A DCT-based Local Feature Extraction Algorithm for Palm-print Recognition", International Journal of Scientific and Technology Research, vol. 1, Issue 2, **(2012)**, pp. 1-8.

[14] S. A. Mistani, S. Minaee and E. Fatemizadeh, "Multispectral Palmprint Recognition Using a Hybrid Feature", Cornell University Library, https://arxiv.org/pdf/1112.5997.pdf, **(2015)** Dec 11.

[15] S. Ribaric and M. Marcetic, "Personal Recognition Based on the Gabor Features of Color Palmprint Images, 2012 Proceedings of the 35th International Convention, IEEE Xplore, **(2012)**, pp. 967-972.

[16] Biometric Research Center, The Hong Kong Polytechnic University, "The Hong Kong Polytechnic University (PolyU) Multispectral Palmprint Database", available at: http://www4.comp.polyu.edu.hk/~biometrics/MultispectralPalmprint/MSP.htm, accessed **(2016)** November 7.

Authors

R. Rizal Isnanto, he Associate Professor in Computer Engineering Department in Diponegoro University, Semarang, Indonesia. Doctoral degree in Electrical Engineering was achieved from Gadjah Mada University, Yogyakarta, Indonesia.

His research interests include biomedical image processing and biometrics as well as in pattern recognition.

Ajub Ajulian Zahra, she Associate Professor in Electrical Engineering Department in Diponegoro University, Semarang, Indonesia. Master degree in Electrical Engineering was achieved from Gadjah Mada University, Yogyakarta, Indonesia.

Her research interests include signal and image processing as well as in telecommunication fields.

Adrian Khoirul Haq, he researcher student in Electrical Engineering Department in Diponegoro University, Semarang, Indonesia. His interest study is in Telecommunication Engineering.

Fachrul Rozy, he researcher student in Electrical Engineering Department in Diponegoro University, Semarang, Indonesia. His interest study is in Telecommunication Engineering.

Palmprint Recognition Systems based-on Backpropagation Neural Network and Euclidean Distance using Principal Components Analysis (PCA) Feature Extraction

PRIMARY SOURCES

1 R. Rizal Isnanto, Ajub Ajulian Zahra, Eko Didik Widianto. "Palmprint recognition system based on principle-lines feature using Euclidean Distance and neural network", 2015 2nd International Conference on Information Technology, Computer, and Electrical Engineering (ICITACEE), 2015
Publication
9%

2 eprints.undip.ac.id
Internet Source
2%

3 Isnanto, R. Rizal. "Iris recognition analysis using biorthogonal wavelets tranform for feature extraction", 2014 The 1st International Conference on Information Technology Computer and Electrical Engineering, 2014.
Publication
1%

4 artikel.ubl.ac.id
Internet Source
1%

5   Sonali N. Deshpande. "Efficient Object Recognition Using Parametric Eigenspace under Influence of Noise and Occlusion", 2008 Ninth ACIS International Conference on Software Engineering Artificial Intelligence Networking and Parallel/Distributed Computing, 08/2008
Publication

1 %

6   ejournal3.undip.ac.id
Internet Source

1 %

7   Isnanto, R Rizal, and Adhi Susanto. "Constructing New Biorthogonal Wavelet Type which Matched for Extracting the Iris Image Features", Journal of Physics Conference Series, 2013.
Publication

<1 %

8   Khan Md. Rabbi, M. Sheikholeslami, Anwarul Karim, Ahmad Shafee, Zhixiong Li, Iskander Tlili. "Prediction of MHD flow and entropy generation by Artificial Neural Network in square cavity with heater-sink for nanomaterial", Physica A: Statistical Mechanics and its Applications, 2020
Publication

<1 %

9   Davari, Azam, and Siamak Esmael Zadeh Khadem. "Automated Diagnosis of Coronary Artery Disease (CAD) Patients Using

<1 %

Optimized SVM", Computer Methods and Programs in Biomedicine, 2016.
Publication

| 10 | eprints.utas.edu.au | <1 % |
| | Internet Source | |

| 11 | advances.utc.sk | <1 % |
| | Internet Source | |

| 12 | www.cired.net | <1 % |
| | Internet Source | |

| 13 | iaescore.com | <1 % |
| | Internet Source | |

| 14 | www.ijera.com | <1 % |
| | Internet Source | |

| 15 | www.mdpi.com | <1 % |
| | Internet Source | |

| 16 | www4.comp.polyu.edu.hk | <1 % |
| | Internet Source | |

Exclude quotes   Off   Exclude matches   Off
Exclude bibliography   On

Palmprint Recognition Systems based-on Backpropagation Neural Network and Euclidean Distance using Principal Components Analysis (PCA) Feature Extraction

FINAL GRADE

/0

GENERAL COMMENTS

Instructor