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Identifying the Quality System of Cocoa Beans to Increase Productivity Using Backpropagation Neural Network Algorithm: A Case Study at Sumber Rejeki Farmers Group, Patuk Gunung Kidul

Lestari U. ✉ , Kumalasanti R.A. ✉ , Wulandari E.S. ✉

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Abstract

An image is a two-dimensional function (x, y) consisting of a number of finite elements. Image processing uses Backpropagation and Principal Component Analysis (PCA) Artificial Neural Networks.

The processed data is the image data of 256 x 256 pixel cocoa beans taken from the Sumber Rejeki Farmer Group (KTSR) with the results of two types of identification output, namely quality cocoa beans and non-quality cocoa beans. The identification process in the system through two stages of the process, namely the training process where the image data of cocoa beans through the training process with input parameters ANN. Image data that has been completed through the training process is used for the testing process. Based on the results of the study using the Backpropagation method with parameters alpha value = 0.35, tolerance value error = 0.05, iteration value = 1000, input neuron value = 255, hidden neuron value = 6, output neuron value = 3 produce quality image data 14 and 6 quality images that are not qualified from the test image data are 20 images of cocoa beans with an accuracy rate of 70% and an error rate of 30%. Based on the tests that have been conducted, it can be concluded that the ANN Backpropagation algorithm can produce a classification of cacao seed quality with a high degree of accuracy. © Published under licence by IOP Publishing Ltd.

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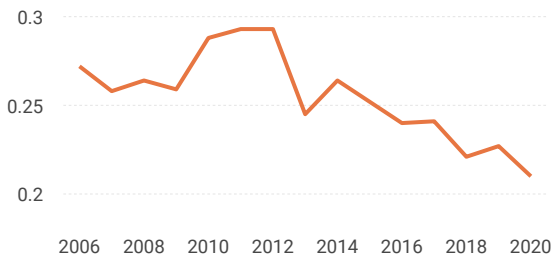
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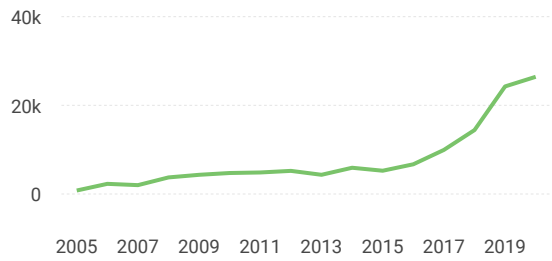
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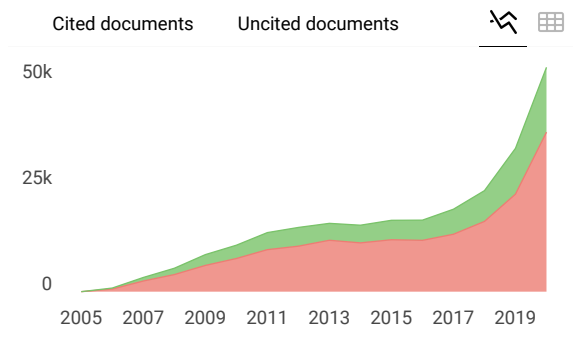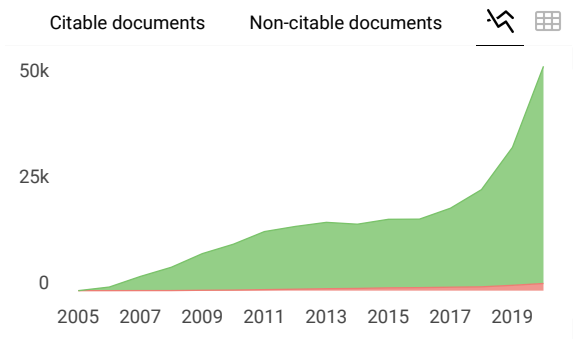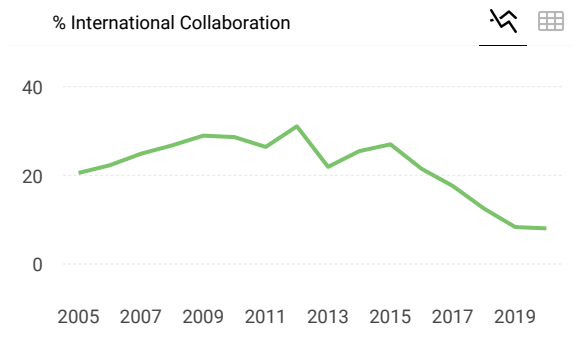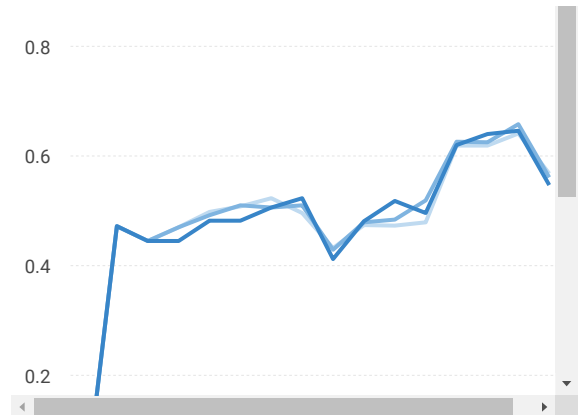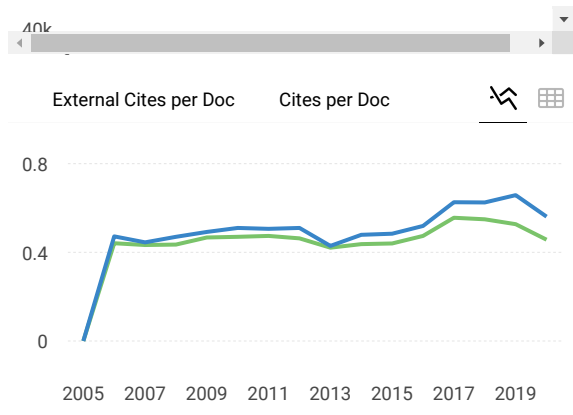
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Preface

On behalf of the ICE-ELINVO organizing committee, I am honoured to welcome you to the 2nd International Conference on Electrical, Electronics, Informatics, and Vocational Education held today, 14th September 2019. This conference is organized by Department of Electrical Engineering Education in cooperation with Department of Electronic and Informatic Education, Faculty of Engineering, Universitas Negeri Yogyakarta.

This conference takes theme "ADVANCING GREEN TECHNOLOGY APPLICATION IN INDUSTRY AND VOCATIONAL EDUCATION". As we know, For the last two decades, the environmental deterioration caused by both human and industry activities has been increasing at alarming level. Numerous efforts have been carried out to alleviate the damage to the environment including the campaign of Green Technology (Greentech) or Clean Technology (Clentech) or Environmental Technology (Envitotech) utilization worldwide.

Greentech is an integration between modern technology and environmental science which is applied to preserve the fulfilment of future community needs without harming the environment. Advanced innovation and education are needed to develop the Greentech. Innovation is set as foundation on invention of environmentally-friendly technological alternatives to meet human needs, while education is channeled as an attempt to improve human awareness in implementing the Greentech which in the long run, leads to a sustainable environment. Therefore, the industries as the inventors of technological innovation and vocational education as the end users of technology must be able to work hand in hand in implementing and evolving the Greentech.

This conference provides a forum for knowledge and experience exchange and we encourage researchers, lectures, teachers, scholars, practitioners, decision maker including the government, and stakeholder to contribute cutting-edge ideas to the Greentech growth.

I realize that you are fully dedicated to the session that will follow but I do hope you will also take time to enjoy the fascinating Yogyakarta city with a vibrant history, friendly people, delicious cuisines, and traditions of Indonesia, which is also renowned as a center of education.

Finally, I would like to express our heartfelt thanks to the committee for enabling this to take place and to everybody who comes to this conference. I wish we will have productive and successful conference

Thank you

Yogyakarta, 14th September 2019
Conference Chairperson
Dr. phil. Nurhening Yuniarti, M.T

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Abstract An image is a two-dimensional function (x, y) consisting of a number of finite elements. Image processing uses Backpropagation and Principal Component Analysis (PCA) Artificial Neural Networks. The processed data is the image data of 256 x 256 pixel cocoa beans taken from the Sumber Rejeki Farmer Group (KTSR) with the results of two types of identification output, namely quality cocoa beans and non-quality cocoa beans. The identification process in the system through two stages of the process, namely the training process where the image data of cocoa beans through the training process with input parameters ANN. Image data that has been completed through the training process is used for the testing process. Based on the results of the study using the Backpropagation method with parameters alpha value = 0.35, tolerance value error = 0.05, iteration value = 1000, input neuron value = 255, hidden neuron value = 6, output neuron value = 3 produce quality image data 14 and 6 quality images that are not qualified from the test image data are 20 images of cocoa beans with an accuracy rate of 70% and an error rate of 30%. Based on the tests that have been conducted, it can be concluded that the ANN Backpropagation algorithm can produce a classification of cacao seed quality with a high degree of accuracy

1. Introduction

Cocoa is a plantation commodity which in recent decades has proven to be an adequate source of income and provides good welfare for farmers. Cocoa commodities are also able to play a role as levers of economic growth, especially in rural areas in production centers. In addition, cocoa also contributes significantly to the acquisition of foreign exchange and absorbs more than one million workers involved in the production and processing and trade sectors. Given this huge role, cocoa has been determined by the government as a priority commodity to be developed. [1]

The statistical data available at the Central Statistics Agency for the area of cocoa plantations in Indonesia in the period of 2012 was 1.77 million hectares, while in 2015 it decreased to 1.70 million hectares and in 2016 amounted to 1.72 hectares. While data on cocoa production in the Special Region of Yogyakarta in 2013 amounted to 853, in 2014 amounted to 1039, in 2015 amounted to 1121, in 2016 amounted to 1057 and in 2017 amounted to 866 with total growth of 7.93%. [2]

The fact shows that there is a continuous increase in world cocoa needs, so that in the future cocoa prices are expected to remain good so that the development of cocoa into new production centers to fill a portion of the world's needs needs to be continued. The results of the research show that in Indonesia

there is still a vast area of land that is suitable for these development needs. Revitalizing existing cocoa areas and developing into new central areas is an action that must be taken by all national cocoa stakeholders to realize Indonesia as the world's largest cocoa producer. [1]

Cocoa plantations in Indonesia have experienced rapid development in the last 20 years and in 2002 Indonesia's cocoa plantation area was recorded at an area of 914,051 ha. Most of the cocoa plantations (87.4%) are managed by the people and the remaining 6.0% are large state plantations and 6.7% are large private plantations. In terms of quality, Indonesian cocoa is not inferior to world cocoa. Nevertheless, Indonesian cocoa agribusiness still faces a variety of complex problems, including low productivity, low product quality and not optimal development of downstream cocoa products. [3]

Quality is a parameter in determining a problem. In determining the quality of cocoa beans itself has several parameters so that determining the quality of cocoa is one of the important aspects in developing sustainable cocoa production and a major factor in consumer satisfaction. To be successful, cocoa farmers should understand the quality from the start. Criteria for the quality of cocoa beans with good quality include full cooking, good fermentation with dry brown seeds, sour smell, no purple or slaty if broken down, not more than 1 gram dry weight, uniform size, non-broken shells and red brownish. (Lampung Agricultural Technology Assessment Center, 2008) Sumber Rejeki Farmers Group (KTSR) is one of the farmer groups in the Patuk sub-district. The Sumber Rejeki Farmers Group was founded in 1980 as a forum for the community to strengthen friendship and sources of sharing agricultural knowledge. The growing age of the Sumber Rejeki Farmers Group also conducted training and established a business to buy wet and dry Cocoa beans. Cocoa beans collected in the Sumber Rejeki Farmer Group are then deposited with the cocoa management officer. Cocoa beans that are deposited to the management officer still use the selection process manually without using parameters but only see the condition of the cocoa beans. The Sumber Rejeki Farmer Group is expected to become a forum for the community to improve economic resources and a place for educating the community to know the parameters for selecting quality cocoa beans. Cocoa beans in the Sumber Rejeki farmer group with a variety of qualities. The cocoa beans were obtained from cocoa farmers from cocoa beans that were still wet, and then by the Sumber Rejeki Farmers Group, they processed wet cocoa beans into dried cocoa beans. The dried cocoa beans will be sold. At this time the determination of the quality of cocoa beans is still manual. Therefore, to find out the quality of cocoa beans with good quality by taking the image of cocoa beans, this study will develop the management of the quality of cocoa beans based on variable texture and color with the image of cocoa beans.

Research on the identification of digital images has been carried out by researchers with various identification objects such as facial images, fruit images, satellite images and others. Digital image processing is a process of improving image quality seen from radiometric aspects (contrast enhancement, color transformation, image restoration) and from geometric aspects (rotation, translation, scale, genetic transformation) by carrying out information withdrawal or object descriptions or object recognition contained in the image other than that there is a process of compression or reduction of data for the purpose of data storage, data transmission and data processing time [4].

The application of digital image processing is expected to be able to provide information for identifying quality with the object of cocoa beans with the results of good and bad quality cocoa beans and can minimize losses if the cocoa beans are sold. The location of the study was conducted at the Sumber Rejeki Farmer Group located in Trosari Hamlet RT / RW 019/006, Salam Village, Patuk District, Gunungkidul Regency, Special Region of Yogyakarta. This application refers to data on cocoa beans in the farmer group. Several previous studies have used the object of cocoa beans and cocoa fruit with various methods and application of the system.

The research discusses the implementation of the Backpropagation method to identify the types of defective cocoa beans based on the shape of the seeds. The method used uses the Backpropagation method. The image processing process by applying the method uses the main data, namely data on cocoa beans with parameters or limitations of the study of the type of defective cocoa beans based on the shape of cocoa beans or edge detection. The system created can help process knowledge from cocoa bean data. The process of identifying the cocoa beans begins by taking the image of the object using the camera,

adjusting the image size, performing grayscale and threshold processes, edge detection or edge detection, image extraction and generating identification results in binary imagery, which is then used for the process data learning. In the research that has been done, the value of learning rate (α) affects the number of iterations of a pattern entered in the data learning process to achieve the iterative termination condition. The results of the research that have been done using the Backpropagation method with alpha = 0.6, hidden layer = 3 fault tolerance = 0.0001, and target = 0.9 produce a system that has an accuracy rate of (76%) and has an error rate (24%) in determining quality of cocoa beans. [5]

Research describes the identification of types of diseases in cocoa by digital image processing and K-Nearst Neighbor. This method is almost similar to clustering, in determining the type of disease in cocoa fruit there are 2 types, namely (1). fruit rot is a disease caused by P. palmiwora fungus which can attack young fruit until cooked. The affected fruit appears blackish brown patches from the base, middle or end of the fruit. (2). Helotopis is a cocoa fruit disease caused by the attack of ladybugs. This disease usually attacks cocoa fruit or young branches of cacao fruit trees. The results of the study were the identification system for cacao fruit using PCA feature image extraction method and K-NN calcification method with an accuracy rate of 86.67%, the size of the image used or the normalized image of 128 x 64 pixels. In the classification process with K-NN, the type of distance method that produces the highest accuracy is the Ciryblock method with k = 1 while the average computation time required for the pre-processing process is 0.31284 seconds, the average computational time for the image extraction process is 0.03598 seconds and the average computation time for the classification process is 0.07774 seconds. [6]

Research on the identification of the maturity quality of cocoa fruit using image processing and fuzzy logic methods has also been done before. This study uses color processing models RGB (red, green, blue) and image histograms. In the fruit classification process based on the characteristics of the same shape or color at the fruit maturity level with mature class groupings having yellow characteristics, the mature setangah class has characteristics of yellowish green and young cocoa fruit has a green characteristic. In applying the fuzzy logic method that is an appropriate way to map an input space into the output space based on the concept of fuzzy sets. The concept of fuzzy logic is used to solve problems that are uncertinly, imprecise, noisy, fuzzy logic as the logic between machine language and human language [7].

Research on pattern matching with the Backpropagation method has also been done before by taking human face objects. The comparison variables used were distance of facial features including nose, eyes and mult from the subject of facial images. In the process of facial recognition, the process of analyzing and identifying faces is done. Face detection includes separating window images with 2 classes namely face (target) and background (clutter). The results of this study are a system that displays humans with high-level facial recognition with a very high degree of accuracy [8].

The Research for describes a pattern recognition system to clarify data patterns and group them according to class also been done before. The purpose of this research is to learn various techniques in recognizing complex patterns, identifying and implementing the best techniques that are appropriate and analyzing results and levels of accuracy. The performance of the pattern monitoring system in this study depends on the type of approach used to identify and clarify the patterns and inputs. If the network model is based on an unsupervised learning approach, then there is no a priori knowledge about a set of classes that has been set and input data differentiated into groups based on structural characteristics or other similar characteristics which can sometimes be a tedious task. If this model is based on a supervised learning approach, the system developed is more accurate and efficient because the network has been trained with the desired results. This engineering approach is better in performance than other techniques because of the high level of accuracy for complex pattern recognition, adaptive learning and better tolerance factors for errors even though more time may be needed to train the network for very complex patterns [9]

Research with the Principal Component Analysis (PCA) and Backpropagation Neural Network methods has also been carried out to identify faces The dimensions of the face image are reduced by PCA and face recognition by the Backpropagation network. This system consists of a database of a

series of facial patterns for each individual with PCA characteristic features called "eigenfaces" extracted from stored images, which are combined with Backpropagation networks for facial recognition. The results of face recognition using PCA and the Backpropagation method with a simulation approach are done with matlab and tested on the ORL face database. This database has more than one individual face image with different conditions. The database is divided into two sets, namely, training databases and testing databases. The network is trained on database training and then one of the images from the testing database is entered as input to test the network [10].

The difference in this identification application with the references mentioned earlier is that this research using the method the Backpropagation method which is added by the Principal Component Analysis (PCA) method and the quality parameters of cocoa beans, namely the texture and color of cocoa beans.

2. Research Methodology
Making an application system through several steps is as follows:

2.1. Data collection
Data collection in the form of digital data or images of cocoa beans. In data collection is done by taking pictures of objects with the help of a digital camera tool. Image taking with dominant white background with image data for each criterion of 10 cocoa beans.

2.2. Resize Image
Resize or resize the image of the cocoa beans to the desired size. In this study the image size of native cocoa beans with a size of 6000 pixels x 4000 pixels and resizing the image of cocoa beans with a size of 256 pixels x 256 pixels with the help of paint desktop applications and JPG image extensions.

2.3. Image input
Image Input Process in implementing the system. Image input by moving image data on the camera into a laptop or storage with the size of the image of cocoa beans 256 pixels x 256 pixels.

2.4. Threshold
The threshold process is the process of changing the image with a degree of gray to a binary or black and white image so that it can be seen which areas include objects and backgrounds of the image clearly. The image from the threshold process is used further for object recognition and feature extraction processes.

2.5. Image Extraction with the Principal Component Analysis Algorithm
Image extraction process or simplifying image data with the Principal Component Analysis (PCA) process by changing the image data of cocoa beans through a linear transformation process. Data that has been extracted as input data in the process of implementing the Backpropagation Algorithm.

2.6. Implementation of Backpropagation Algorithm
The sixth step in the research is implementing an algorithm from the Backpropagation method. Backrpopagtion algorithm is an algorithm with the application of artificial neural networks. Backpropagation is a supervised learning method that has a target to be sought. The process of applying the Backpropagation method is used in two stages, namely the training stage, where at this stage a number of training data and targets are given and the testing phase is carried out after Backpropagation has finished learning.

2.7. Input image
The next step is image input which is the result of the image data of cocoa beans that have gone through the process of image resizing, threshold, image extraction with Principal Component Analysis and

implementation of the Backpropagation method stored in the datastore. Data stored in the datastore is used as data in the process of testing the image to obtain information on the quality of cocoa beans.

2.8. Image Testing

The last step is to test the image, this step is used to determine the results of the image data that has been obtained in the input image and the application of the Backpropagation algorithm. Image testing with image data that has been stored in the data store with the image data of cocoa beans which will later in the process of testing the image will produce conclusions of the quality of the ideals of the cocoa beans. In addition, this testing process is also used to determine error tolerance and accuracy by applying the Backpropagation method.

3. Results

The results of image testing in the form of information on the image of cocoa beans that are of good quality and not good quality. In the process of determining the quality of cocoa beans there are several parameters in determining the quality used. Parameters determining the quality of cocoa beans can be seen in Figure 1 [12].

No	Picture	Name	Description
1		Full Fermentation	Brown cocoa beans are full of hollow texture. The fermentation process is complete
2		Partial Purple	Some cocoa beans are purple and some are brown. This is generally produced from an imperfect fermentation process.
3		Full Purple	Full purple cocoa beans. This is result from a short fermentation process (less than 1 weeks)
4		Slaty	Cocoa beans are purple and grey and have a solid texture. This results from a short fermentation process (less than 3 days)
5		Moldy	Cocoa beans are brown and there is fungus in the texture cavity of the cocoa beans. This is result from the imperfect fermentation process

Figure 1. Parameters determining the quality of cocoa beans

4. Results and Discussion

The results of the system application for identifying the quality of cocoa beans consist of two main processes, namely the Training Process and the Testing Process. Whereas button access consists of Output Target, Read Training Image, Initial Weight, Training Process, Read Test Image and Testing Process.

4.1. Training Process Stage

The initial appearance of the application for identifying the quality of cocoa beans consists of two processes, namely the Training Process and the Testing Process. The application for identifying the quality of cocoa beans begins with the Training process by determining the target output of each criterion (Slaty, Full Purple, Full Purple, Full Fermentation, Molding) then selecting the Image Read button to

determine the training image data stored in the database to be processed in training process. In this process an example is taken for the target criteria of Slaty. The process of determining the target of Salty's output criteria can be seen in Figure 2. After all the criteria, namely Slaty, have finished reading the image, they are automatically stored in the database.

After the process is complete, the next step is to get values for weight V and W. By pressing the Initial Weight button then weights V and W randomly appear in the weight table V and W. This initial weight button serves to generate initial weights for weight V (weight between input and hidden layers) and W weights (weights between hidden layer and output layer). After the initial weight is raised, it will be saved automatically in the database. The next step is to determine the values of the parameters of Artificial Neural Networks which include Alpha values, Tolerance values, Iteration values, Input Neuron values, Hidden Neuron values, Output Neuron values. In this process using that Alpha value is 0.35, the tolerance value is 0.05, and the number of iterations is 1000. These values can be changed according to the requirements for each training process. The value of input neurons is 255 and cannot be changed because it is the number of eigenvalues of training images measuring 256 x 256 pixels. A 256 x 256 pixel image produces an eigenvalue of 255. The value of a hidden neuron is 6 and the output neuron value is 3 because it corresponds to the target number of each cocoa image criterion. After the process of determining parameters, the values of each parameter have been completed, the next step is to do the training process by pressing the training button.
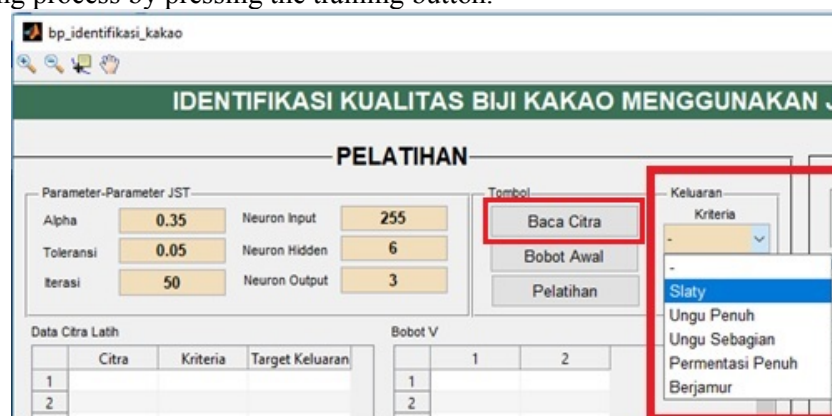
Figure 2. Process for Determining Target Criteria for Slaty

The training process will take place according to predetermined iteration and tolerance parameters. The training iteration process will continue as long as the error value of the training process is greater than the set tolerance value. If the error value of the training process is smaller than the tolerance value, the iteration of the training process will end. Conversely, if the error value of the training process is greater than the tolerance value, the training process will continue to take place in accordance with the number of iterations that have been determined.

In the dialog box, it can be seen that the number of iterations is 466 and the error value is 0.049949 which is smaller than the predetermined tolerance value of 0.05 and the computing time for the training process is 666.2426 seconds. The training process will produce a weight V and a new W weight called the trained weight term. This trained weight will be used to carry out the identification process. Weight V and weight W the training results will be displayed in the table and the results of the trained weights are automatically stored in the database.

4.2. Testing Process Stage

After the training process is completed, proceed with the Testing process, namely selecting the test image that will be used as test data in the database. This process is done by pressing the Read Image button in the testing process. After selecting the test image in the database, the results will be displayed in the test image table by displaying the image name and image size. The testing process will produce

identification data which can be seen in Figure 3. Test image data in the testing process produces 14 recognizable image data according to the criteria but there are 6 data that cannot be recognized. The testing process requires computation time of 0.69412 seconds.
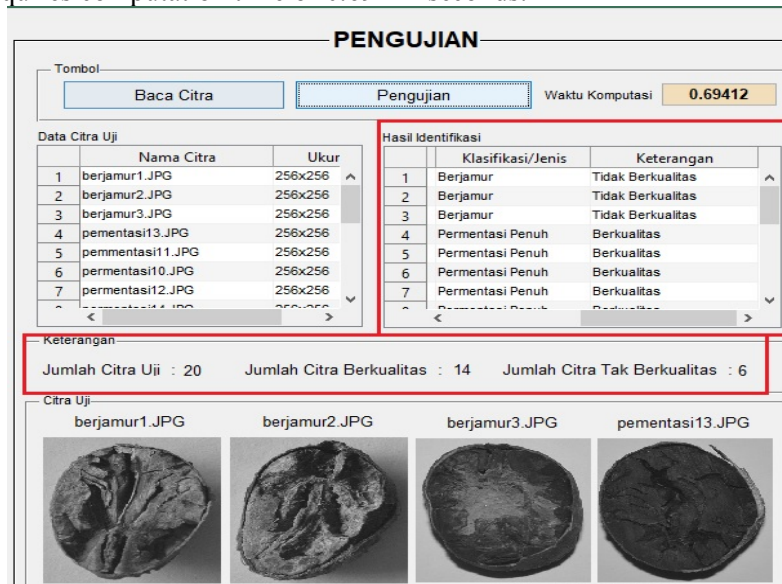

Figure 3. Display of Test Results

4.3. Analysis of System Results

The application for identifying the quality of cocoa beans using the Backpropagation method in the implementation process requires several additional methods in the identification process. In the training process or learning process in the Backpropagation method additional methods are needed, namely the image extraction process using the Pricipal Component Analysis (PCA) method. This method was added to facilitate the process of image recognition of each criterion of cocoa beans. The extraction process with PCA is used to find eigenvalues from the image of cocoa beans. In the process of extracting images with PCA the results obtained to be implemented in the Backpropagation method, namely with 256 x 256 pixel size images, an eigenvalue of 255 is obtained in the parameters of Artificial Neural Networks (ANN) as input neurons. The structured process in image extraction with PCA in the pre-training process can be seen in Figure 4.

After the image extraction process with PCA, it can be done using the Backpropagation method starting from the training process and then testing. In the training process eigenvalue data from the image of each criterion can be processed so as to produce test image data and corvergency graphs. The training process begins after the image extraction process with PCA is completed and then determines the initial weight and parameters of Artificial Neural Networks (ANN). The initial weight between weight V and Weight W is obtained randomly from weights V (hidden neurons and input neurons) and W weights (output neurons and hidden neurons). The appearance of the training process can be seen in Figure 5

The training process is carried out if the PCA process has been completed and the eigenvalues of each image are stored in the datastore. The training process begins by taking or obtaining a value of weight V and weight W obtained randomly. Furthermore, determining the parameters of Artificial Neural Networks (ANN) include alpha value = 0.35, tolerance value of 0.05, iteration value = 1000, input neuron value = 255, hidden neuron value = 6 and output neuron value = 3, After process the training was carried out in the application of the Backpropagation method and then the testing process was carried out. After the parameters have been completed, the training process can be started so that the output results in the form of a convergence graph and the training results dialog box are obtained.
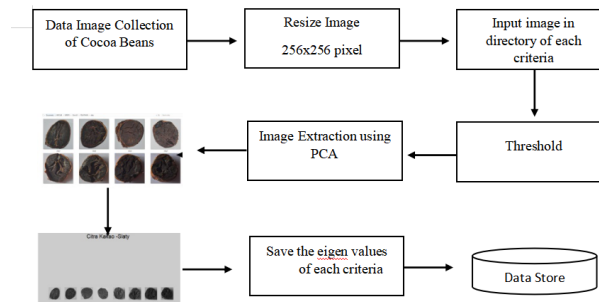
Figure 4. PCA Process

After conducting the training process, the next step is to conduct a testing process that produces identification results in accordance with the quality of each of the criteria for cocoa beans. The output of the identification results is in the form of images of good quality cocoa beans and non-quality seeds. The appearance of the testing process can be seen in Figure 8.
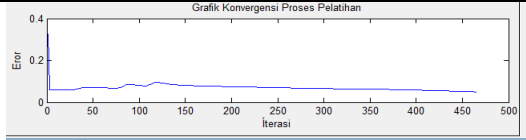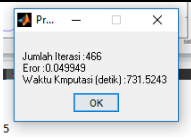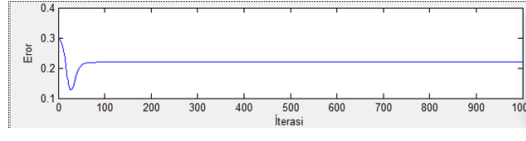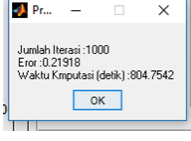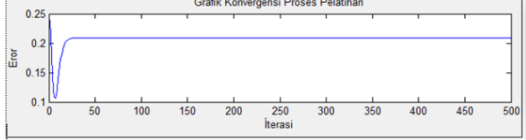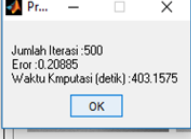
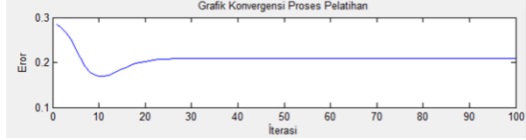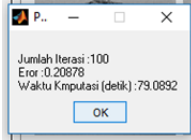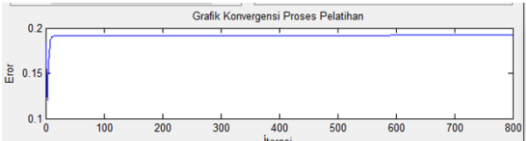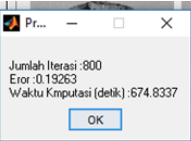In the testing process begins by selecting a test image that will be carried out by the testing process with the output of a quality and non-quality image in accordance with the parameters that have been carried out in the training process. In the process of identifying the quality of cocoa beans it was carried out with 5 simulations to get the right results and accuracy in determining the quality of good and non-quality cocoa beans with the appropriate ANN parameters. The test simulation process can be seen in Table 1.

In addition to carrying out the testing simulation process, a discussion of the manual calculation process was carried out in identifying the quality of cocoa beans as follows: alpha value = 0.35, tolerance = 0, $X1 = 1$, $X2 = 1$ with hidden neurons = 3. Weight obtained randomly with a value weight V and weight W in Table 3 and Table 4.
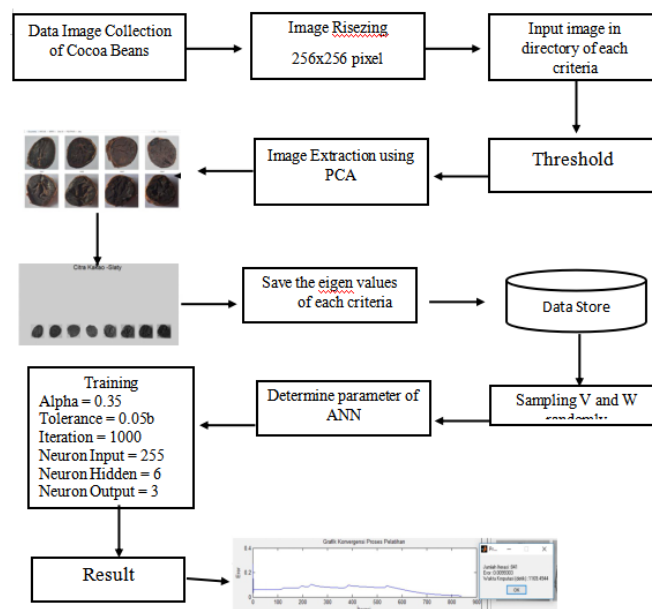
Figure 5. Training Process

Table 1. Convergence Charts and Dialog Boxes

No	Convergence Graph	Dialog Box
1		
2		
3		
4		
5		

Table 2. Test Simulation Results

No	Artificial Neural Network Parameters						Result (B/TB)	Accuracy
	Alpha	Tolerant	iterasi	Neuron input	Neuron hidden	Neuron output		
1	0,35	0,05	1000	255	6	3	B = 14, TB = 6	70%
2	0,02	0	1000	255	3	3	B = 0, TB = 20	0%
3	0,05	0,1	500	255	1	3	B = 0, TB = 20	0%
3	0,05	0,1	500	255	1	3	B = 0, TB = 20	0%
5	0,10	0	800	255	3	3	B = 0,TB = 20	0%

Table 3. Latest V Weight Table

	Z_1	Z_2	Z_3
X_1	-0,003	0,004	-0,002
X_2	-0,001	0,006	-0,007
1	-0,001	0,006	-0,020

Table 4. Latest W Weight Table

	Y_1	Y_2	Y_3
Z_1	0,022	0,071	0,061
Z_2	0,080	0,032	0,027
1	0,111	0,147	0,088

The implementation of the back propagation method in the application of the quality identification of cocoa beans in grouping categories or criteria from cocoa bean data is done manually based on direct observation in the field. The manual grouping process of this manual category consists of full, purple, purple, full, slaty and moldy fermentation criteria. The process of grouping categories in research with image data of cocoa beans took training samples of 8 images each from 5 criteria and 20 test images.

5. Conclusion

With the identification system using the Backpropagation method to determine the quality of cocoa beans in the Sumber Rejeki Farmer Group (KTSR) with quality and non-quality results, we can conclude:

(1) Based on the results of the study using the Backpropagation method in the process of identifying quality, it gives an output of the image of quality and non-quality cocoa beans. In the simulation process, it is obtained that with alpha parameter value = 0.35, tolerance value = 0.05, iteration value = 1000, input neurons = 255, hidden neurons = 6, and output neurons = 3, there are 14 quality cocoa beans and the image of non-quality cocoa beans is 6 out of 20 test image data with an accuracy rate of 70% and an error rate of 30%.

(2) Based on experiments or simulations that have been carried out, the value of the parameters of Artificial Neural Networks (ANN) affects the results in the process of identifying the quality of cocoa beans to produce a high degree of accuracy.

(3) By using a computerized system, the process of identifying the quality of cocoa beans is able to provide a smaller level of error and help Farmers in determining the quality of cocoa beans.

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