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Color based feature extraction and backpropagation neural network in tamarind turmeric herb recognition

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Abstract

The aim of this paper is finding the optimum image pattern of the tamarind turmeric herb. So far, in the process of producing tamarind turmeric herb, it is not constant in terms of taste and color, which is influenced by maturity and the amount of turmeric. Image pattern recognition will use Backpropagation algorithm applied to typical Content-based image retrieval systems. The main purpose is to apprehend various parts of tamarind turmeric herb in the retrieving processing. The camera is applied to classify the tamarind turmeric herb product, process into 5x5 pixels, and take an average of the RGB value so the stable RGB values will be obtained in each category and used as input for Backpropagation algorithm. The most suitable and the fastest process from the Backpropagation algorithm will be searched and applied in a real-time machine. In this paper will be using two methods, first, train the algorithm using ten data by change neuron, layer, momentum, and learning rate, and the last is testing with ten data. The results obtained from the training and testing algorithm that the two hidden layers can recognize 100% inputs, with three input layers used for R, G, and B value, ten neurons in the first hidden layers and the second hidden layers, one output layer with a parameter used is Learning rate 0.5 and Momentum 0.6. The best image pattern standard for tamarind turmeric herb is dark yellow with RGB values of 255, 102, 32 up to 255, 128, 48.

1. Introduction

The culture of the Indonesian people is to consume herbal medicines, one of which is the tamarind turmeric herb. Currently, this culture is becoming a trend due to the Covid-19 Pandemic. Tamarind turmeric herb contains vitamin C that comes from the color of turmeric [1]. Vitamin C can maintain the body's immunity to avoid transmission of the covid-19 virus [2][3][4]. Consuming 500 mg of curcumin every day can increase the body's immunity. The taste of the tamarind turmeric herb depends on the color of the product [5][6]. The color of the herbal medicines will determine the vitamin C consumed. With this phenomenon, a system is needed that can maintain the vitamin C content in the sour turmeric herbal medicine. Where the system can stabilize the color of herbal medicine production, even though the production is carried out by different people.

One of the successes factors in the tamarind turmeric herb can be seen from the color produced, where the yellow color of the tamarind turmeric herbal medicine should not be too bright. Although the composition of turmeric used is in accordance with the standards, the resulting color is always different. This depends on the maturity level of the turmeric used, but until now there is no definite standard to see, measure and determine whether the color is in accordance with the standards given by the business owner. The process of mixing turmeric and tamarind ingredients on a monitored basis can be an alternative that can help obstacles in the herbal medicine business. Where the system will check the weight of each material used and then monitor the resulting color results. Researchers have used artificial neural networks as research material that was used from 1987 until now [7][8]. Backpropagation (BP) which is part of the Neural Network has been tested in many studies [9]–[16]. Image Processing is used to process the data before it is processed by the Artificial Neural Network [17]–[27]. One of the results that can be obtained from Image Processing is the RGB value [28]–[33].

Previous research concluded that BP could recognize input well with various forms of algorithms that have been made [9]–[16]., but with a different system, a new algorithm is needed that can be used for color classification in the production of tamarind turmeric herb. So, this research would provide good accuracy and precision to provide standard products even though the level of maturity of Turmeric is different and produced by others. This research will discuss the BP training and testing algorithm so that the best architecture can recognize colors from production and provide color standards so that the herbal products have the same results.

2. Research Method

2.1 Tamarind Turmeric Herb

Tamarind turmeric herb is a herbal medicine made from turmeric, and tamarind which is efficacious to refresh the body or can make the body cool. There are also those who say it is useful to avoid heartburn or canker sores, and make the stomach cool. The herbal ingredients used for the jamu turmeric acid are 1 kg of turmeric, 1 kg of tamarind, ½ kg of brown sugar, 1 kg of white sugar and 28.6 g of salt. The process of making tamarind turmeric herb begins with washing the turmeric and cutting it into smaller pieces then measuring all the required ingredients such as turmeric, acid, sugar and salt then putting it into the cooking tank, after reaching a certain temperature and the color of the turmeric has come out then a color check will be carried out and will be added. If the turmeric doesn't match the color, when it boils it will be left for a while before turning off the stove and continuing with the cooling and packaging process.

One of the problems faced by the tamarind turmeric herb production industry is the change in the quality of the sour turmeric decoction that is produced will also change along with the change in production operators. The most striking difference lies in the color of the sour tamarind turmeric herb produced. Even though the owner has a definite dose, the color of the tamarind turmeric herb will still change because it depends on the type of turmeric and the different age factors of turmeric. The color content of turmeric will also affect the quality of taste and nutrition in herbal medicine. So even though there is already a turmeric weight determined by the business owner, this does not guarantee that the quality of the herbal medicine will be the same in every production.

The quality of turmeric turmeric herb can also be seen from the color of the herbal medicine produced. Where to use Backpropagation Neural Netwotk method can be applied to recognize patterns. Then cluster the recognized patterns, so that there is minimal error. By recognizing the pattern to be the most optimum point of herbal medicine with quality a high value can be obtained that the value will continue to be standardized with the same value although the type of turmeric is different. There are several methods or stages that will be carried out including Image Acquisition, Image Processing, Data Normalization, Backpropagation Classification and Real-time Testing. The proposed method of recognizing the tamarind turmeric herb is depicted in Figure 1.

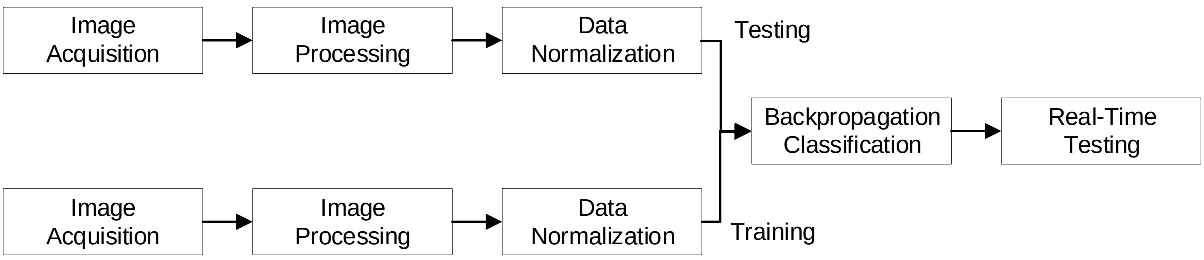

Figure 1. The Method of Recognizing the Tamarind Turmeric Herb

2.2 Image Acquisition

Image acquisition was used camera to collected the sample data. Based on brightness each sample is classified into 3 different color Dark Yellow (DY), Yellow (Y), and Light Yellow (LY). DY have 20 images with range 255, 102, 32 up to 255, 128, 48, Y have 20 images with range 255, 130, 34 up to 255, 158, 44, and LY have 20 images with range 255, 160, 45 up to 255, 180, 52. The total sample data is 60, which 30 is used as training, another 30 is used for testing.

2.3 Image Processing

Image Processing is the stage used to process images obtained from the camera so that they can be processed as input in the Backpropagation Neural Network method. Image Processing consists of 3 stages are cropping, averaging, and feature extraction processes is depicted in Figure 2. The success of a Backpropagation Neural Network architecture can be seen from how the image processing system must be carried out. The more images obtained in accordance with the specified standard, the easier it is for the Backpropagation Neural Network method to recognize the given input pattern.

Figure 2. Image Processing

a. Cropping

Cropping is a process to improve readability of image. Cropping is used to remove noice. This process will crop centre of the image into 5x5 pixels resolution. The example of cropped images can be seen in Figure 3.

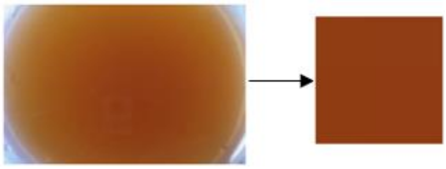

Figure 3. Cropping Process

b. Averaging

Averaging is a process to obtain a representative RGB value. This process wil take an average from all 25 pixels into one result. The example of averaged images can be seen in Figure 4.

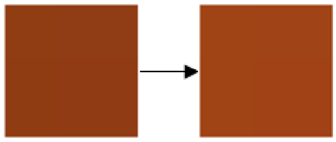

Figure 4. Averaging Process

c. Feature Extraction

Feature extraction is a pattern that is defined and can be identified through its characteristics that used to distinguish one pattern from another. in this study, feature extraction will obtain value from avareged image into red, green, and blue value or called RGB. Based on cartesian coordinate system, each color of RGB model appears in its primary spectral components of red, green, and blue.

2.4 Data Normalization

In this study, backpropagation network parameters were initialized using small random numbers, and often behave poorly when the feature values are much larger than parameter values because feature values were passed through individual units, it is important to normalize all feature values at the same scale or called data normalization. Data normalization was carried out using Min-Max Normalization [data normalization reff]. This method rescales the range of the RGB (0 to 255) to (0.1 to 0.9). The formulation of this method is as follows in Equation 1.

$$Value = \left(\frac{0{,}8 * (dataValue - minValue)}{maxValue - minValue}\right) + 0{,}1 \quad (1)$$

2.5 Backpropagation

Backpropagation has multiple units present in one or more hidden layer. The Figure 5 is a backpropagation architecture with n inputs (plus a bias), a hidden layer consisting of p units (plus a bias), and m output units.

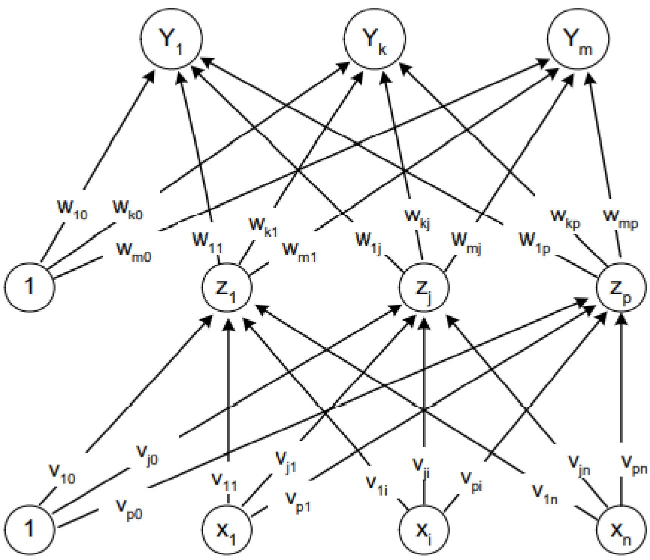

Figure 5. Backpropagation Architecture

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The training algorithm for a network with one hidden layer is as follows:
Step 0: Initialize all weights with small random numbers.
Step 1: If the termination condition is not met, do steps 2 – 9.
Step 2: For each pair of training data, do steps 3 – 8.
Phase I: Forward propagation.
Step 3: Each input unit receives the signal and forwards it to the hidden unit above it.
Step 4: Count all outputs in hidden units $z_j\ (j = 1, 2, \ldots, p)$ as follows in Equation 2 and Equation 3.

$$z_{net\,j} = v_{jo} + \sum_{i=1}^{n} x_i v_{ji} \tag{2}$$

$$z_j = f\left(z_{net_j}\right) = \frac{1}{1 + e^{-z_{net_j}}} \tag{3}$$

Step 5: Count all network outputs in the unit $y_k\ (k = 1, 2, \ldots, m)$ as follows in Equation 4 and Equation 5.

$$y_{net\,k} = w_{ko} + \sum_{j=1}^{p} z_j w_{kj} \tag{4}$$

$$y_k = f\left(y_{net\,k}\right) = \frac{1}{1 + e^{-y_{net\,k}}} \tag{5}$$

Phase II: Backward propagation.
Step 6: Calculate factor δ output units based on the error in each output unit $y_k\ (k = 1, 2, \ldots, m)$ in Equation 6.

$$\delta_k = \left(t_k - y_k\right) f'\left(y_{net_k}\right) = \left(t_k - y_k\right) y_k \left(1 - y_k\right) \tag{6}$$

δ_k is the unit of error that will be used in changing the weight of the layer below it (step 7).
Calculate the rate of change of weight w_{kj} (which will be used later to change the weight w_{kj} with the Learning rate (Lr) as follow in Equation 7.

$$\Delta w_{kj} = Lr\ \delta_k z_j \tag{7}$$

$k = 1, 2, \ldots, m\ ;\ j = 0, 1, \ldots, p$
Step 7: Calculate factor δ hidden units based on errors in each hidden unit $z_j (j = 1, 2, \ldots, p)$ as follow in Equation 8.

$$\delta_{net\,j} = v_{jo} + \sum_{k=1}^{m} \delta_k w_{kj} \tag{8}$$

Factor δ hidden unit as follow in Equation 9.

$$\delta_j = \delta_{net_j} f'(\text{z\_net}_\text{j}) = \delta_{net_j} z_j \left(1 - z_j\right) \tag{9}$$

Step 8: Calculate all changes in weight by adding momentum Mc.
Change in the weight of the line leading to the output unit as follow in Equation 10.

$$w_{kj}(new) = w_{kj}(old) + \Delta w_{kj} + Mc\left(w_{kj}(old) - w_{kj}(old - 1)\right) \tag{10}$$

$(k = 1, 2, \ldots, m;\ j = 0, 1, \ldots, p)$

Change the weight of the line leading to the hidden unit as follow in Equation 11.

$$v_{ji}(new) = v_{ji}(old) + \Delta v_{ji} + Mc\left(v_{ji}(old) - v_{ji}(old-1)\right) \quad (11)$$

$(j = 1,2,\dots,p;\ i = 0,1,\dots,n)$

After the training is complete, the network can be used for pattern recognition. In this case, only forward propagation (steps 4 and 5) is used to determine the network output.

a. Training

The training process is carried out to train backpropagation to recognize the tamarind turmeric herb using 30 sample data. The training prosess will be continued until MSE is less than 0,000001. The training process is shown in Figure 6.

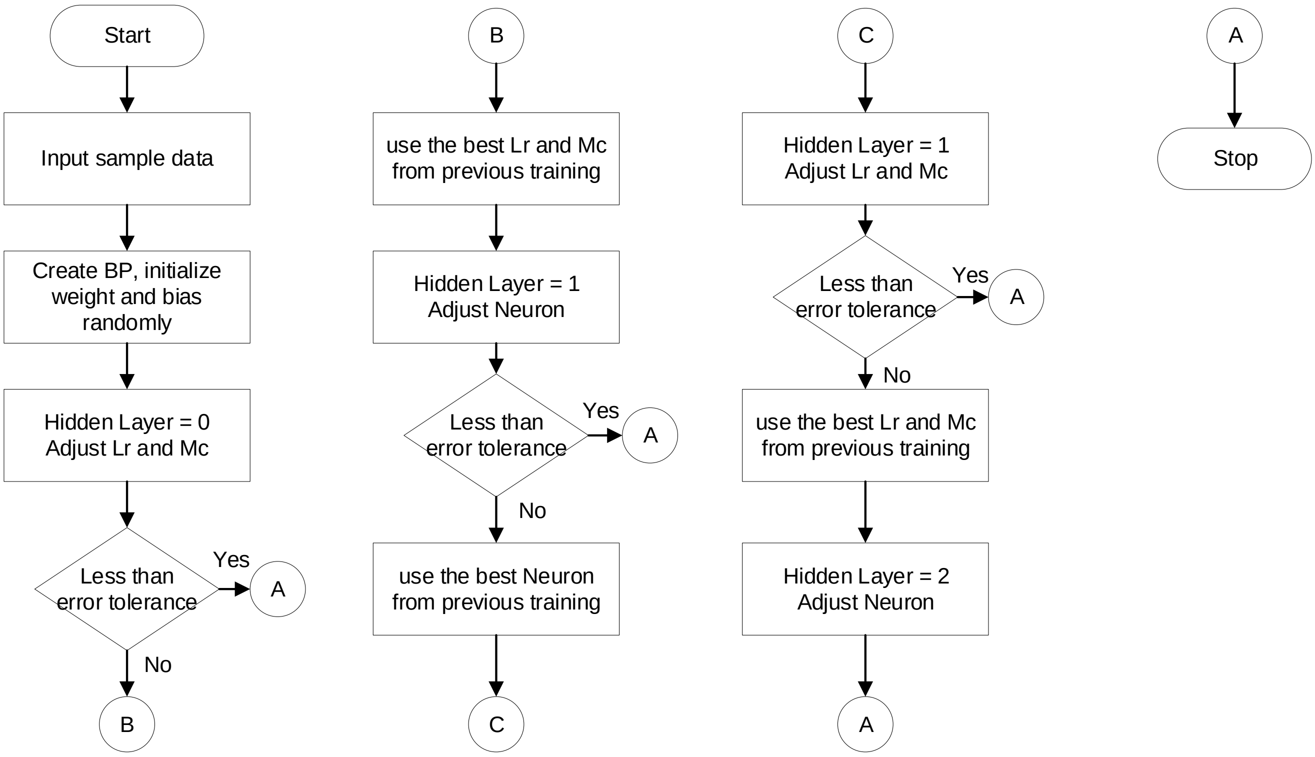

Figure 6. Training Process

The Backpropagation Neural Network Training process begins with inputting sample data. Then we will generate BP with random weight and bias initialization. With the hidden layer value = 0, then we have to adjust the Lr and Mc values. After obtaining the least error tolerance value, we can use the best Lr and Mc from previous training.

Then we will change the value of Hidden Layer to 1 and adjust the neuron. Then training is carried out until less than error tolerance. This neuron value will be used for further training. After getting the best neuron value, with a hidden layer value of 1, we can adjust Lr and Mc again to determine the best value. We change the value of the hidden layer to 2 and adjust the neuron again to get the best neuron value in condition 2 hidden layer.

b. Testing

The testing process is carried out using to validate the training result using 30 different sample data. This process is expected to be able to recognize all the sample data.

2.6 Real-Time Testing

After designing the backpropagation architecture in the previous subsection, the next step is Real-Time Testing in the direct herbal boiling process is shown in Figure 7. The first thing to do is to embed trained backpropagation into a minicomputer. When the herbal medicine is boiling, the minicomputer will capture the image using the camera. After obtaining the herbal color samples, image processing and backpropagation classifications will be carried out. The classification results will be displayed on the LCD screen. Real-time testing aims to test trained backpropagation in tamarind turmeric herb production. The testing process is shown in Figure 7.

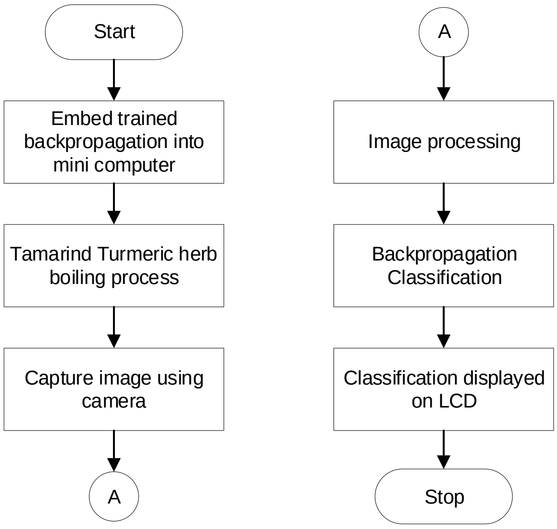

Figure 7. Testing Process

3. Results and Discussion

3.1 Image Processing

The image processing aims to extract features from the tamarind turmeric herb so that the BP could recognize the feature. This experiment was carried out with 60 images. The simulation result is obtained by capturing an image from tamarind turmeric herb using camera and then extracting RGB value. The output value from image processing can be seen in Table 1.

Table 1. Output Value from Image Processing

Dark Yellow			Yellow			Light Yellow		
R	G	B	R	G	B	R	G	B
255	109	36	255	133	39	255	162	45
255	113	34	255	135	43	255	165	47
255	113	41	255	134	41	255	170	47
255	107	48	255	131	42	255	170	46
255	102	42	255	158	40	255	178	52
255	107	41	255	140	36	255	166	46
255	104	32	255	144	34	255	180	50
255	103	33	255	147	37	255	168	51
255	117	35	255	150	41	255	180	46
255	128	36	255	151	44	255	174	45
255	106	39	255	130	39	255	160	45
255	111	40	255	135	43	255	164	47
255	106	35	255	133	41	255	169	47
255	108	35	255	134	42	255	170	46
255	107	32	255	156	40	255	178	52
255	109	32	255	141	36	255	167	46
255	108	35	255	143	34	255	181	50
255	107	33	255	149	37	255	168	51
255	105	32	255	151	41	255	180	46
255	106	39	255	150	44	255	177	45

The data that will be used is the RGB value of the production of tamarind turmeric herb the data in Table 1 is obtained by taking a sample of the color of tamarind turmeric herb according to the needs and requests of partners in 3 color classifications, namely dark yellow, yellow, and light yellow every color has 20 data, for each 10 data is used for training and testing. The training data is used to train the algorithm, while the testing data is used to determine the performance of the previously trained algorithm when it finds new data that has never been seen before. This is usually called a generalization. The results of the training can be called a model. The network training process begins with defining network inputs and targets which is used to design the network structure from the results of the test data retrieval. Then the initial weight and bias values are determined randomly and will be stored for trial and error during the training. The training aims for the network learning process to recognize input patterns and classify them.

The training process will end when the error is corrector equal to the target (MSE 10e-05). The testing process is carried out using new data to determine the success rate of the existing network being trained. The parameters used in the training process are LR, Mc, MSE, Gradient, Epoch, time, neurons, and class test, where the class test is the result of the introduction of 3 types of colors ranging from light yellow, yellow and dark yellow with 10 data each. Color recognized as light yellow has RGB values between 255, 162, 40 to 255, 180, and 52. Yellow color is between 255, 131, 39 to 255, 158, 44. Dark yellow color is between 255, 103, 32 to 255, 128, 48.

3.2 Data Normalization

The data in Table 1 is then normalized using the matlab application so that the results of the normalization data are obtained in Table 2. The results are obtained using the formula on Equation 1. From the Table 2, we see that data normalization using Min-Max Normalization able to rescales 0 to 255 RGB value to 0.1 to 0.9 range.

Table 2. Data Normalization Result

Dark Yellow			Yellow			Light Yellow		
R	G	B	R	G	B	R	G	B
0,9000	0,4420	0,2129	0,9000	0,5173	0,2224	0,9000	0,6082	0,2412
0,9000	0,4545	0,2067	0,9000	0,5235	0,2349	0,9000	0,6176	0,2475
0,9000	0,4545	0,2286	0,9000	0,5204	0,2286	0,9000	0,6333	0,2475
0,9000	0,4357	0,2506	0,9000	0,5110	0,2318	0,9000	0,6333	0,2443
0,9000	0,4200	0,2318	0,9000	0,5957	0,2255	0,9000	0,6584	0,2631
0,9000	0,4357	0,2286	0,9000	0,5392	0,2129	0,9000	0,6208	0,2443
0,9000	0,4263	0,2004	0,9000	0,5518	0,2067	0,9000	0,6647	0,2569
0,9000	0,4231	0,2035	0,9000	0,5612	0,2161	0,9000	0,6271	0,2600
0,9000	0,4671	0,2098	0,9000	0,5706	0,2286	0,9000	0,6647	0,2443
0,9000	0,5016	0,2129	0,9000	0,5737	0,2380	0,9000	0,6459	0,2412
0,9000	0,4325	0,2224	0,9000	0,5078	0,2224	0,9000	0,6020	0,2412
0,9000	0,4482	0,2255	0,9000	0,5235	0,2349	0,9000	0,6145	0,2475
0,9000	0,4325	0,2098	0,9000	0,5173	0,2286	0,9000	0,6302	0,2475
0,9000	0,4388	0,2098	0,9000	0,5204	0,2318	0,9000	0,6333	0,2443
0,9000	0,4357	0,2004	0,9000	0,5894	0,2255	0,9000	0,6584	0,2631
0,9000	0,4420	0,2004	0,9000	0,5424	0,2129	0,9000	0,6239	0,2443
0,9000	0,4388	0,2098	0,9000	0,5486	0,2067	0,9000	0,6678	0,2569
0,9000	0,4357	0,2035	0,9000	0,5675	0,2161	0,9000	0,6271	0,2600
0,9000	0,4294	0,2004	0,9000	0,5737	0,2286	0,9000	0,6647	0,2443
0,9000	0,4325	0,2224	0,9000	0,5706	0,2380	0,9000	0,6553	0,2412

3.3 Backpropagation

The experiment of backpropagation was carried out in 2 stage are training and testing. Training result is obtained by 30 data from sample data images and Testing using 30 data from sample data images as shown in Table 3.

Table 3. Training Result

Hidden Layer	Lr	Mc	Neuron	MSE	Epoch	Time	Output	Percentage	DY	Y	LY
0	0.5	0.2	0	0.0561	3	2	Unreached	0%	0	0	0
0	0.5	0.4	0	0.0416	3	1	Unreached	0%	0	0	0
0	0.5	0.6	0	0.0393	3	1	Unreached	0%	0	0	0
0	0.5	0.8	0	0.0590	3	1	Unreached	0%	0	0	0
0	0.2	0.5	0	0.0368	3	1	Unreached	0%	0	0	0
0	0.4	0.5	0	0.0434	3	1	Unreached	0%	0	0	0
0	0.6	0.5	0	0.0446	3	1	Unreached	0%	0	0	0
0	0.8	0.5	0	0.0563	3	1	Unreached	0%	0	0	0
1	0.5	0.6	1	0.0381	30	2	Unreached	43%	6	2	5
1	0.5	0.6	2	0.0393	29	2	Unreached	30%	4	3	2
1	0.5	0.6	3	0.0198	210	9	Unreached	46%	3	3	8
1	0.5	0.6	4	$1.36e^{-06}$	14	1	Reached	90%	10	7	10

1	0.5	0.6	5	2.82e^{-06}	12	1	Reached	96%	10	9	10
1	0.5	0.6	6	4.47e^{-06}	7	1	Reached	100%	10	10	10
1	0.5	0.6	7	4.11e^{-06}	8	2	Reached	100%	10	10	10
1	0.5	0.6	8	5.55e^{-06}	10	1	Reached	90%	10	7	10
1	0.5	0.6	9	2.01e^{-06}	12	1	Reached	100%	10	10	10
1	0.5	0.6	10	4.93e^{-07}	12	1	Reached	100%	10	10	10
1	0.5	0.2	10	8.48e^{-06}	12	1	Reached	100%	10	10	10
1	0.5	0.4	10	4.09e^{-06}	9	2	Reached	93%	10	8	10
1	0.5	0.6	10	3.81e^{-07}	9	1	Reached	100%	10	10	10
1	0.5	0.8	10	9.35e^{-06}	15	1	Reached	80%	4	10	10
1	0.2	0.5	10	7.78e^{-06}	24	1	Reached	96%	10	9	10
1	0.4	0.5	10	7.48e^{-06}	11	2	Reached	93%	10	9	9
1	0.6	0.5	10	8.19e^{-06}	13	1	Reached	100%	10	10	10
1	0.8	0.5	10	4.39e^{-08}	13	2	Reached	100%	10	10	10
2	0.5	0.6	10-1	4.43e^{-06}	7	1	Reached	100%	10	10	10
2	0.5	0.6	10-2	3.56e^{-06}	33	1	Reached	100%	10	10	10
2	0.5	0.6	10-3	6.80e^{-06}	18	1	Reached	100%	10	10	10
2	0.5	0.6	10-4	4.48e^{-06}	9	1	Reached	100%	10	10	10
2	0.5	0.6	10-5	1.36e^{-06}	18	1	Reached	100%	10	10	10
2	0.5	0.6	10-6	1.42e^{-06}	9	1	Reached	100%	10	10	10
2	0.5	0.6	10-7	7.58e^{-06}	10	1	Reached	100%	10	10	10
2	0.5	0.6	10-8	6.38e^{-07}	10	1	Reached	100%	10	10	10
2	0.5	0.6	10-9	6.23e^{-06}	7	1	Reached	93%	10	8	10
2	0.5	0.6	10-10	8.26e^{-09}	19	1	Reached	100%	10	10	10

Table 3 shows that the result of training. The experiment result was obtained by simulating backpropagation in Matlab. The experiment is arranged in such a way as shown in Figure. From the Table we can see that the best backpropagation algoritm with minimum MSE is 2 hidden layers with 10 neurons in each layer, Lr 0.5, and Mc 0.6. The system will never recognize the current image of the algorithm without using a hidden layer. So, the algorithm must use hidden layers, the next step is to determine the number of hidden layers used.

Table 4. Best Backpropagation Algoritm

Hidden Layer	Lr	Mc	Neuron	MSE	Epoch	Output	Percentage	DY	Y	LY
1	0.5	0.6	10	2.85e^{-06}	16	Reached	100%	10	10	10
2	0.5	0.6	10-10	1.69e^{-09}	6	Reached	100%	10	10	10

Table 4 shows that the result of testing the result of 1 hidden layer and 2 hidden layers. Determination of the best network apart from the largest network performance is also viewed from the ability to recognize each class in the classification. So that the best network is obtained that is able to recognize all classes with a training rate of 0.5 and a momentum of 0.6. the epoch count is 19 with a training time of 1 second.

From the training, a network with 2 hidden layers 10-10 has a small value and can recognize 100% input. Then a test will be carried out by comparing 1 hidden network with 10 neurons and 2 hidden networks with 10-10 neurons, the parameters and are the same, namely 0.5 and 0.6, Table 4 shows that the 2 hidden layers have lowest MSE and 100 accuracies.

3.4 Real-Time Testing

Real-time testing was obtain based on Figure 7. The result of the experiment can be shown in Table 5.

Table 5. Real Time Testing Result

Hidden Layer	Turmeric Concentration	Classification	Target	Output
1	35%	Light Yellow	Light Yellow	Reached
1	65%	Light Yellow	Yellow	Unreached
1	95%	Dark Yellow	Dark Yellow	Reached
2	35%	Light Yellow	Light Yellow	Reached
2	75%	Yellow	Yellow	Reached
2	95%	Dark Yellow	Dark Yellow	Reached

The Table 5 is obtained by boiling the tamarind turmeric herb directly in the cooking tank and then taking data directly using 1 and 2 hidden networks with parameters such as Backpropagation Neural Network architecture testing. From the Table 5, 2 hidden layers can classify correctly all the experiment. Because with using 1 hidden network could not yet recognize the color yellow, this was evidenced by the RGB value which should be recognized as yellow, but recognized as light yellow.

Research using backpropagation has been carried out to detect tumor diseases through X-ray images of the brain [12]. Compared with those studies, the proposed model achieves an improved accuracy of 93% in detecting tumor disease. The results obtained through the new algorithm in this study is 2 hidden layers 3-10-10-1 with Lr 0.5 and Mc 0.6 can reach 95% accuracy, this proves that the algorithm obtained can be 2% more than the previsious research.

4. Conclusion

From the research above, several conclusions can be drawn, first, training without hidden layer cannot recognize input at all, second, training with 1 and 2 hidden layers shows the best architectural results, namely 2 hidden layers 3-10-10-1 with MSE 8.26e- 09, The three test results from 1 and 2 hidden layers found that 2 hidden layers can recognize all inputs, fourth, from the results of training and testing it can be concluded that the best network or architecture for this research is 2 hidden layers 3-10-10-1 with Lr 0.5 and Mc 0.6. The best color standard for tamarind turmeric herb, which is dark yellow with an RGB value of 255, 103, 32 to 255, 128, 48 because every single step of the experiment can recognize.

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