Design and Development of California Papaya Murability Detection Based on Learning Vector Quantization Method Using LDR Sensor and Camera

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Abstract. Sorting the ripeness of papaya fruit is generally done manually. Technological developments can simplify and speed up the work of farmers in sorting papaya fruit, such as using the TCS3200 series LDR sensor, which produces red, green, and blue color frequency values. This sensor can distinguish ripe papaya fruit from different skin colors. Papaya with perfect green skin color is included in raw papaya, papaya with balanced green and yellow skin color means that papaya is mature, and papaya with even yellow skin color is included in ripe papaya. This category is also included in the class in the classification of papaya fruit maturity using the LVQ method. The data is taken directly using the camera by classifying it using the parameters of mean, skewness, and kurtosis. The results of the highest papaya ripeness classification accuracy are in the 2nd experiment with a learning rate value of 0.2 with hidden layer ten (10) and epoch 100, which is 93.3%, and the test results of the whole tool have an average success percentage value of 69.41%.

Keywords: Papaya · TCS3200 series LDR · Camera · Learning Vector Quantization (LVQ)

1 Introduction

Technology is growing rapidly so that more and more human needs depend on technology, both in communication, education, and even in the plantation sector. Fruit is a profitable commodity because of its diversity and supported by a suitable climate, resulting in a variety of very varied and interesting fruits that can be found throughout Indonesia [1].

One type of fruit plant that is very popular in the community is papaya (Carica papaya L.) [2]. Papaya fruit is a fruit that does not know the seasons; papaya production in Indonesia for the last three years starting from tends to be stable at 958,251 in 2011, 906,305 in 2012, and 909,818 in 2013 (units of a ton). Papaya fruit is sometimes seen with one eye, even though this fruit is synonymous with a healthy lifestyle. Papaya is one type of fruit with a selling value and a high content of vitamin C and fiber, so it is good for consumption to launch the body's digestive process [3].

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One of the types of papaya fruit is the California papaya, the California papaya is the result of plant breeding from the Tropical Fruit Study Center of the Bogor Agricultural University (PKBT-IPB) under the name IPB-9 or Calina. These small papayas are more oval with an average weight of 1.3 kg per fruit. This plant can thrive throughout the year (regardless of season) in Indonesia [2].

Processing of papaya fruit is not only ripe; raw papaya can be used for a mixture of pecel and can be used for salad ingredients or a mixture of sour vegetables, while ripe fruit is processed into fast food, packaged drinks, and others. The maturity level of the fruit can be seen from several aspects, namely the color, shape, and aroma of the fruit [1]. The ripeness of the fruit can be seen by adjusting the color of the ripe fruit, and the fruit is tested for its level of maturity when viewed from the aspect of the color [4]. The difference in maturity gives a difference in the appearance of surface properties so that it can be captured by machine vision [5]. Papaya entrepreneurs still use the manual method to distinguish papaya maturity, namely by looking at the color of the papaya skin and massaging the fruit to determine the texture of the papaya fruit [6]. In contrast, the method used by human labor is often inaccurate and varies in its determination [7].

Papaya fruit should be picked when the fruit gives a sign of maturity, namely the color of the fruit skin begins to turn yellow, but there are still many farmers who pick it when the fruit is not yet ripe. Papaya must be harvested at the right time according to the level of maturity. When harvested, the fruit will ripen normally and produce fruit with a good aroma and taste. Farmers and traders usually use discoloration of the skin. The degree of ripeness is determined by the degree of yellowness seen, and the harvest is carried out depending on the purpose of the market. Fruits sent to distant markets are usually harvested when the skin color of the new fruit is slightly yellow because at this level of color, the fruit can last longer (not quickly rot) [8].

Based on the existing problems, it is necessary to detect the optimum level of papaya ripeness, which is quite selective, objective, economical and accurate, and for the freshness of papaya fruit during the distribution and storage process. The process of ripening papaya fruit can be done by utilizing camera technology and LDR (Light Dependent Resistor) sensor technology. The working principle of LDR is that when light is given at a certain light intensity on the surface of the papaya skin, the reflected light is captured by the sensor and passes through a filter or filter, so if the color is the same then the filter will absorb the light [9]. The LDR can improve the quality of papaya fruit in order to support technological advances in the field of food and agriculture.

Image processing is a method or technique that can process images or images by manipulating them into the desired image data to obtain certain information. Image processing applications provide convenience to process an image. The use of image processing technology is expected to increase accuracy in determining the ripeness of fruit. The condition of the fruit can be approximated from the size of the object in the image when it is taken with a contrasting background with the observed fruit color [10].

The application of fruit ripeness detection has been previously investigated, among others, in tomatoes, watermelons, cucumbers, and chilies [10]. In addition, research in image processing related to fruit ripeness through color detection on fruit skins, either using a computer or smartphone, has been carried out by several previous researchers. One of them is a study entitled Introduction to Paya Rabo Papaya Rise Levels Using

Image Processing Based on RGB Colors with K-Means Clustering. In this study, the image processing method was carried out using the red, green, and blue values to analyze the ripeness of papaya [11]. The study by determining the ripeness level of papaya with ANN using 7 RGB color characteristics, HIS color, and texture as input and aging levels. (young, old, mature) as the output [12].

Information and communication technology used in this case study is a design for detecting the maturity level of California papayas based on LDR sensors and cameras to be classified using the learning vector quantization method. The method in question is a training method for learning in a supervised competitive layer (supervised learning) whose network architecture is a single layer (single layer). The advantage of the LVQ method is its ability to provide training to competitive layers so that it can automatically classify a given input vector [13].

The advantage of using this method is that the error value is smaller than that of artificial neural networks such as backpropagation, while the disadvantage is that the accuracy of the model depends on the initialization of the model and the parameters used (learning rate, iteration, etc.) [14].

2 Research Method

This study designed a papaya fruit maturity tool with the help of the TCS3200 series LDR sensor by taking the RGB value on the papaya skin. This research was paired with an ultrasonic sensor to adjust the distance to the papaya to be classified according to the level of maturity. The size of the California papaya is not always the same, some are small, and some are large. The hardware design in this study uses the TCS3200 series LDR sensor. The sensor can read color at 2 cm to 4 cm. Therefore an ultrasonic sensor is used for this design as a spacer between papaya and TCS3200. This research is equipped with a NEMA17 motor as a driver to raise or lower the sensor box. This design also

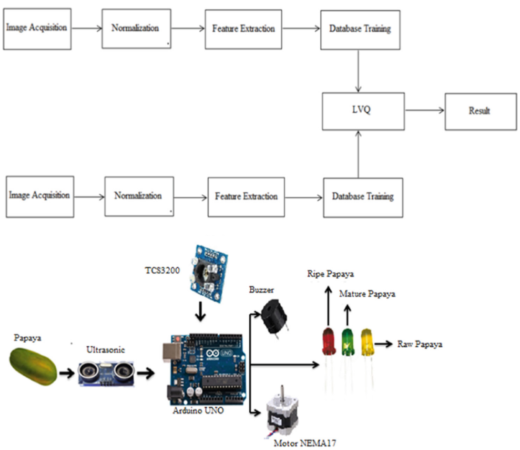

Fig. 1. Research Block Diagram

uses a camera as a papaya image to be classified using the learning vector quantization (LVQ) method.

In simple terms, the research process is explained using the following research block diagram (Fig. 1).

Next is the research stage to classify papaya fruit maturity using the LVQ method. The first stage is image acquisition by taking pictures of papayas where they will be provided and made in such a neat manner with the aim that the results obtained are more accurate and focused so that the noise produced is less, then the next step is normalization, namely cutting the image to become smaller to speed up computing and reduce the computer workload, next is feature extraction, namely the process to determine the level of ripeness of papaya fruit from the color of the papaya skin produced and then the last stage is the results obtained from the image will be classified using LVQ (Learning Vector Quantization) and will produce output with information on the level of maturity of ripe, half-ripe and unripe fruit.

3 Results and Discussion

3.1 TCS3200 Series LDR Sensor Testing

The TCS3200 series LDR (Light Dependent Resistor) sensor is used for detecting an object or the color of the monitored object. The TCS3200 LDR (Light Dependent Resistor) sensor in this design is used to detect the level of color brightness on the papaya skin to detect the level of maturity. Tests were carried out with the help of colored paper to compare the results obtained. After being validated with color paper, the TCS3200 test was carried out on papaya directly using 3 papayas directly including ripe papaya, half-ripe papaya and unripe papaya. Here are pictures and tables of test results (Fig. 2 and Table 1).

3.2 Ultrasonic Sensor Test

The HC-SR04 sensor detects the papaya's distance with the color sensor. This sensor test aims to determine the distance between the TCS3200 color sensor and papaya because

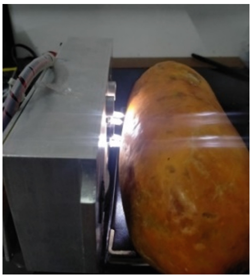

Fig. 2. Testing the TCS3200 Sensor

Table 1. Tcs3200 Test Results

No	Types of Papaya	Distance (cm)	Test score			Description
			R	G	B	
1	Ripe Papaya	2	92	133-135	202-210	Detected
		2-3	117	132-135	183-191	Detected
		4	129	106-112	192-200	Detected
2	Half ripe papaya	3	129-133	130-135	226-231	Detected
3	Raw Papaya	2	221-225	223-250	282-324	Detected
		3-4	230	186-191	238-247	Detected

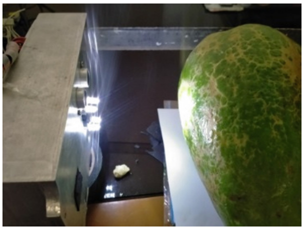

Fig. 3. Testing the TCS3200 Sensor

it is known that the color sensor can only detect within a maximum distance of 4 cm. This test is done by placing a papaya object in front of the ultrasonic sensor. The sensor reading distance starts with a distance of 1 cm to a distance of 15 cm. (Table 4.3) shows that there are several distances there are differences in readings on the ultrasonic sensor; at a distance of 1 cm, the sensor detects 2 cm and produces an error value of 1% than at a distance of 2 cm, 4 cm, 10 cm, and 11 cm there is a difference in readings between the sensor and the sensor. The actual value, the overall error value generated in this ultrasonic test, is 0.12%.

Testing on this papaya object produces an error value because the surface of the papaya fruit is not flat, so ultrasonic waves cannot reflect perfectly (Fig. 3).

3.3 Overall Tool Test

The overall test is carried out, namely when the papaya to be tested inserted into the box, the first one that will read is the distance sensor, where when the distance read is <= 11 cm, the NEMA17 motor will move downwards so that the sensor box that has been installed parallel to the motor will follow down. The motor will continue until the proximity sensor detects a distance of 2 cm to 4 cm. After the motor stops, the TCS3200 series light sensor will take data for a few seconds. The data from the TCS3200 sensor has been read, and then the motor will go back up to its original state, which is at a distance of 11 cm. The motor will automatically stop when the distance has read a distance of 11 cm. The overall test can be seen in Fig. 4 .

Figure 4 is the overall test result where the test is carried out in a papaya box with a sensor placed in another smaller box. The test was carried out by taking data on 37 different papayas, the papayas tested included 10 unripe papayas, 11 half-ripe papayas and 16 unripe papayas. The test results can be seen in Table 2.

Fig. 4. Overall Testing of Papaya Fruit Ripe

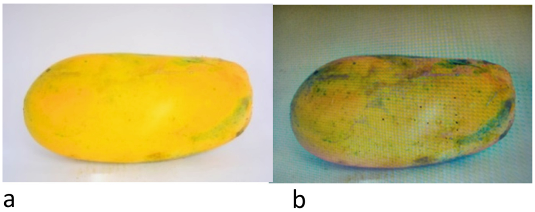

Fig. 5. Contrast Sharpening (a) Original Image, (b) Edgesharp Image Result

Fig. 6. Image Segmentation Results

3.4 Matlab Testing

3.4.1 Preprocessing Results

The papaya fruit ripeness test was carried out using a Logitech C270 camera installed on the sensor box, then classified using the learning vector quantization method. The input image in this Matlab test uses image data as much as 45 data; 30 data is used for training data, including 15 images of ripe papaya, 15 images of papaya in dry condition, 15 images of raw papaya, and 15 images of papaya image as testing data). The existing data is preprocessed, namely the resizing process or changing the pixel size with 3008 $\times$ 2000 pixels converted to 455 $\times$ 315 pixels. The next process is to separate the object from the background and then sharpen the contrast of each color layer using CLAHE (Figs. 5 and 6).

The last stage is to combine the three layers by replacing the area with a value of 1 to have a color intensity like the actual image. The results of image segmentation can be seen in the following figure.

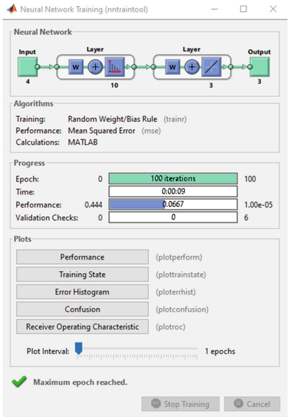

Fig. 7. Neural Network Training Data

3.4.2 Learning Vector Quantization (LVQ) Classification Results

The classification process uses the LVQ (Learning Vector Quantization) method to classify the type of ripe papaya fruit tested, consisting of ripe papaya, half-ripe papaya fruit, and unripe papaya. The test is based on the results of characteristic ecstasy that have been carried out, namely with the parameter values of means, skewnew, kurtosis, and standard deviation. The research data consisted of 45 papaya image data consisting of 30 training data and 15 data for testing. The training data consists of 15 mature image data, 15 half-ripe image data, and 15 raw image data. The training data consists of 15 image data, each of which is 5 mature image data, 5 fixed image data, and 5 raw image data. The test was carried out 5 times with different learning rate values, namely a learning rate of 0.1 to 0.5.

3.4.3 Learning Vector Quantization (LVQ) Training

Learning vector quantization is used to classify papaya fruit ripeness. This LVQ training is carried out repeatedly to get the number of neurons in each layer or layer, weights, and parameters in the optimal training process. This training consists of input data for 3 classes, and the output is 3 classes, namely the mature class, the half-ripe class, and the raw class. The neural network used in training uses epoch 100. More details can be seen in the following picture.

Figure 7 shows the display of the training process on the papaya fruit maturity system, and this training process stops at the 100th iteration according to the given set. This training process takes 9 s and produces a performance value of 0.0667. The graph of performance can be seen in Fig. 8.

Figure 8 shows a training performance graph that produces the best performance value at epoch 91 with an MSE value of 0.66667. Next is to see the results of the target confusion matrix and the training output shown in Fig. 9.

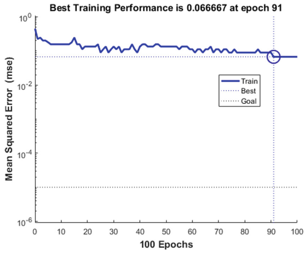

Fig. 8. Graph of Training Performance Data

Fig. 9. Comparison of Training Targets and Training Output

3.4.4 Learning Vector Quantization (LVQ) Testing

Testing on the classification of papaya fruit maturity is done by changing the learning rate value from 0.1 to 0.5 with different hidden layers, namely 5 and 10; the epoch value is 100.

The test data was carried out on 15 papaya image data and divided into 3 classes, including 5 ripe papaya images included in the ripe class, 5 half-ripe papaya images included in half-ripe papaya, and 5 unripe papaya images included in the unripe class. The results of this test can be seen in Table 2.

Based on the tests carried out with the hidden layer 5 value and the learning rate value from 0.1 to 0.5, it can be concluded that the greater the input learning rate value, the smaller the accuracy value generated. The accuracy in the test resulted in the highest value, namely in the 1st experiment with a learning rate of 0.1, which was 86.67%, and the smallest accuracy value was found in the 5th experiment, with a learning rate of 0.5, which was 60%.

Testing with a hidden layer value of 10 and a learning rate value from 0.1 to 0.5, it can be concluded that the greater the input learning rate value, the smaller the resulting accuracy value. The accuracy in the test resulted in the highest value, namely in the 2nd experiment with a learning rate of 0.2, which was 93.3%, and the smallest accuracy value was found in the 5th experiment, namely with a learning rate of 0.5, which was 66.67%.

Table 2. Overall Quantizatian Learning Vector Test Results

No	*Hidden Layer*	*Learning Rate*	*Epoch*	Ripe		Half-ripe		Raw		Accuracy
				1	0	1	0	1	0	
1	**5**	**0,1**	**100**	**4**	**1**	**4**	**1**	**5**	**0**	**86,67%**
2	5	0,2	100	3	2	3	2	5	0	73,3%
3	5	0,3	100	5	0	3	2	4	1	80%
4	5	0,4	100	3	2	3	2	5	0	73,3%
5	5	0,5	100	2	3	2	3	5	0	60%
6	10	0,1	100	4	1	4	1	5	0	86,67%
7	**10**	**0,2**	**100**	**5**	**0**	**4**	**1**	**5**	**0**	**93,3%**
8	10	0,3	100	5	0	4	1	4	1	86,67%
9	10	0,4	100	5	0	4	1	4	1	86,67%
10	10	0,5	100	2	3	3	2	5	0	66,67%

4 Conclusion

Based on the research results that have been done, it can be concluded as follows.

- The design of a tool to detect papaya ripeness using the TCS3200 series LDR sensor has been successfully made. The results can be proven by the tool's success in detecting and distinguishing ripe papaya, half-ripe and unripe. The accuracy value in the test tool for ripe papaya is 56.25%, papaya is 72%, and raw papaya is 80%, so it has an average accuracy value of 69.41%.
- The camera used for data collection in the form of images has been installed in a sensor box together with the LDR and TCS3200 sensors. The classification of papaya fruit maturity level using the learning vector quantization method has the highest accuracy value in the 2nd test, 93.3%, and the lowest is in the 5th test, 66.67%.

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