Fruit Classification using Neural Network Model

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***Abstract*—Fruit classification process is gaining importance in image processing applications specifically in agricultural area. However, classification process is challenging for images captured in natural environment due to the existence of non-uniform illumination. Different illuminations produce different intensity on the object surface and thus lead to inaccurate classification. Therefore, this study focuses on the improvement of development of classification model for images captured in natural environment. This study has developed a neural network (NN) model that is able to classify objects based on their surface colour. The result of the NN model shows that, with the network configuration of 6-7-4, the NN model works very well for objects exposed to the natural illumination. To justify the proof-of-concept, the proposed classification model is tested on jatropha fruit images and the results show that the developed model is able to classify the fruit accurately.**

***Index Terms*—Fruit Classification; Neural Network Model; Natural Environment.**

I. Introduction

Classification is a process to classify unknown patterns from new objects to the nearest category of trained pattern. A classification technique has become very important in crop yield area because it assists farmers and crop agencies to classify fruit into correct maturity level based on the fruit features. The main purpose of this study is to categorize jatropha fruit based on colour feature. Jatropha curcas L. is one of the jatropha species which belongs to the Euphorbiaceae family. This crop has potential value as a bio-diesel resource [1-3] because the seed of jatropha contains approximately 40 percent of oil and can be processed into fuel. In agricultural industry, classifying jatropha fruit is very significant because the fruit should be picked at the appropriate maturity stages in order to get an optimum oil yield.

The texture, colors and smell of the fruits are often used by human inspectors to judge fruit maturity. Among these attributes, colour is the most significant physical attribute that can distinguish the levels of jatropha fruit maturity [3,4]. However, grading the fruit based on colour feature manually is a time consuming and inconsistent process. Misjudgment of the color often happens due to different color perception from human's eyes [5,6] especially with the presence of changes in illumination.

Alternatively, image processing technique has become more popular and reliable in classifying fruit maturity levels. An analysis on fruit images not only offers a non-destructive approach but it also provides an accurate and cost effective technique for automated grading system. In order to classify fruit automatically and effectively, a classification technique was extensively applied in a fruit grading system. However, most of the classification techniques were conducted in controlled environment.

Therefore, the main purpose of this study is to produce a classification technique that is able to help crop industry to classify fruit in natural environment accurately and effectively.

The remainder of this paper is organized as follows. Section 2 presents overview of classification technique neural network (NN) model. Section 3 is then presents the experiments of jatropha classification process using this model. In this section, an explanation on the development of NN model is also presented. Subsequently, Section 4 discusses the results obtained from the experiments. Finally, Section 5 provides the conclusions of this study.

II. Classification Technique and Neural Network Model

Classification technique has been used for many years to classify investigated objects in many areas such as agriculture [7,8]. In agricultural area, the classification techniques have been used extensively in classifying fruits such as jatropha [9], dates [10,11], oil palm [12,13] and mango [14,15]. These studies have proved that the classification techniques are able to assist humans in classifying fruits automatically and accurately.

However, the classification process becomes more challenging for classifying fruit in natural environment due to the presence of direct illumination on the object surface. The misjudgment of colour happens due to the existence of lightness which closely correlated with surface reflectance [16,17]. Therefore, some images might be wrongly classified into incorrect category.

In order to evaluate the classification accuracy with the presence of lightness on the images, this research employed classification technique to investigate relationships among data attributes and capture meaningful patterns in the data. Currently, there is no study reported in the literatures examines the accuracy of classification technique in classifying jatropha based on images captured in natural environment. Therefore, this research aims to produce an effective classification technique that is able to classify the fruit correctly and accurately.

Recent years, NN has become a popular computing approach in data classification and predictive applications. NN is an artificial representation of the human brain that emulates the structure and the functionality of the brain. This approach was also called an artificial neural network

(ANN) where it can be trained to learn a complex relationship between two or more variables. One of the main advantages that make NN so attractive is its ability to learn patterns or relationships between the given input and targeted output [8,18].

Chokananporn and Tansakul [19] have used NN model to predict surface area of guava. In the research, a feed-forward network with 20 nodes in the hidden layer was developed and the performance of this model was compared with regression models. The results show that the NN model was better than regression models in predicting the surface area of guava fruit.

Zulham et al. [9] also used a feed-forward BP in their research to classify jatropha maturity based on colour. In this study, the maturity stages were classified into three categories; raw, ripe and overripe which represented by green, yellow and black colours, respectively.

The feed-forward BP NN was also used by Zhang et al. [20] to identify jujube tree diseases. The NN model was able to categorize the diseases into six categories (rust, anthracnose, white rot, fruit rust, ascochyta spot and witches broom) based on colour, morphological and texture features with high accuracy rate.

The review of literatures shows that NN models are viable and very significant for fruit classification process in agricultural area. However, the classification for different fruits involved different architecture of NN models. Due to the excellent performance of NN, this research used the technique to classify jatropha in natural environment. NN model was used as a function of predictors that minimize the prediction error of target variables.

III. Fruit Classification using Neural Network Model

There are four primary steps involved in classifying objects using neural network model which are; 1) construction of fruit datasets, 2) creating the neural network model, 3) training the network model, and 4) testing the network model.

A. Construction of Fruit Datasets

For classification process using NN, the dataset of 200 jatropha fruit images was used. The jatropha fruit was chosen because it has four different categories based on surface colours indicating its maturity stage. The categories are green (immature), yellow (under mature), yellowish-brown (mature), and black (over mature). These images were captured using Nikon Coolpix S8100 digital camera. Samples of the captured images are shown in Figure 1.

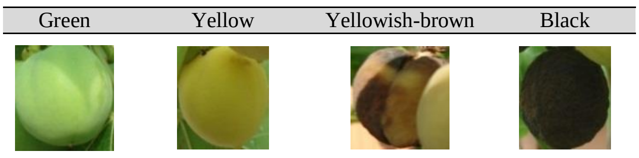

Figure 1: Samples of Jatropha Images

The decision to use four categories in this research was made based on several previous researches. Malaysian Agriculture Research and Development Institute **(**MARDI**)** and Zulham et al. [9] classify jatropha into three classes of maturity which are unripe, ripe and overripe. However, research on jatropha oil yield by Achten et al. [21] shows that yellowish-brown fruit is the best stage of fruit maturity for harvesting the jatropha. Therefore, yellowish-brown colour was included in this research to represent a mature category.

Next, all the captured images were segmented to extract only the fruit area and remove the background by using TsNKM segmentation method [22]. These images were then processed using superimpose algorithm adapted from Mendoza [23] to produced superimposed images in RGG format as shown in Figure 2.

This dataset was then partitioned into two subsets of data which are training set and testing set. For this research, the distribution of each set was approximately 50% for training (100 data) and 50% for testing (100 data). Each category of images in both training and testing sets were selected equally (50 images per category) from the original data to minimize the bias in the selection.

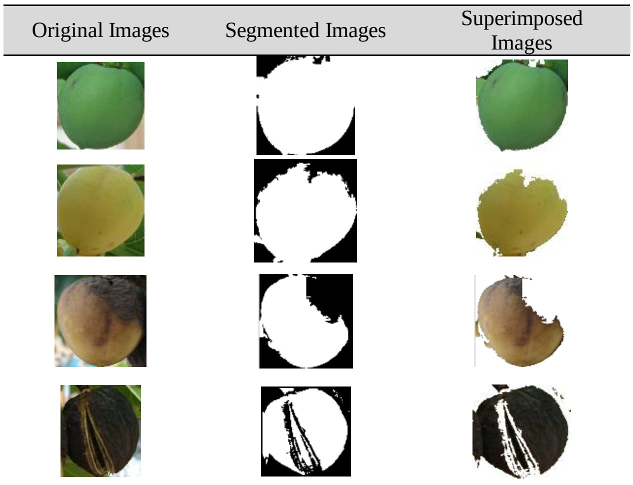

Figure 2: Superimposed Images in RGB Format

For this research, colour was chosen as a significant attribute to classify jatropha fruit. Therefore, colour analysis was conducted to extract the colour information from the fruit surface and store the information as fruit datasets. The dataset contains colour elements of 200 jatropha fruit images.

For each of the 200 fruit samples, the value of each colour element was determined using the average values of the pixels. Results in Table 1 show a sample of R, G, B and L*, A* and B* values for four images. Image 1, 2, 3, and 4 represent the immature, under mature, mature and over mature fruit, respectively.

Table1
Values of RGB and LAB for Different Categories of Jatropha

Image	R	G	B	L*	A*	B*
1	141.47	183.45	91.78	84.75	-18.12	26.43
2	151.15	144.98	60.27	78.34	-8.89	34.38
3	129.57	102.73	62.31	69.56	1.59	20.76
4	36.70	33.27	24.79	42.18	-0.55	8.65

B. Creating the Neural Network Model

In this study, the multilayer perceptron (MLP) neural network model was created. The MLP network was chosen because of two reasons. First, MLP has the ability to train the network to be generalized within the range of inputs. Second reason for choosing MLP was because of its ability to learn both linear and non-linear relationship directly from the data being modeled [20, 24]. In general, the architecture of NN model for this research contains three layers; 1) input layer, 2) one hidden layer, and 3) output layer.

The input layer consisted of six neuron, $\{x_1, x_2, x_3, x_4, x_5, x_6\}$ where each neuron represents the colour elements; R, G, B, L*, A* and B*, respectively. The input layer received the input signal and then distributed the signal to all the neurons in the hidden layer. The number of neurons in the hidden layer was seven and it was sufficient to produce a good prediction result. The output layer contains four neurons, $\{t_1, t_2, t_3, t_4\}$ where each represents immature, under mature, mature and over mature, respectively. The outputs of neurons in the output layer were the output of the network. Eventually, the developed NN classification model consists of 6 neurons in the input layer, 7 neurons in the hidden layer and 4 neurons in the output layer. Hence, the network configuration is 6-7-4 as shown in Figure 3.

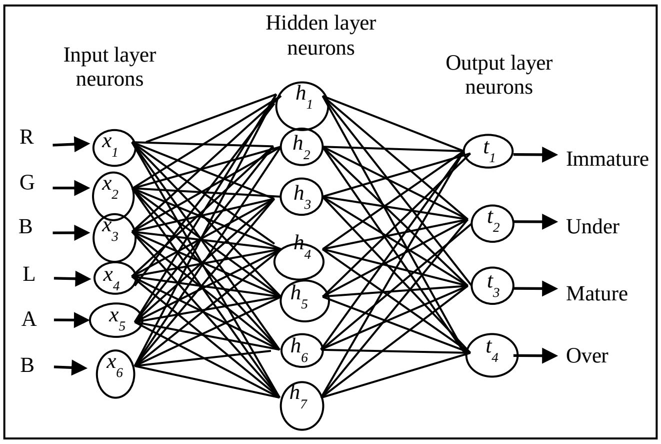

Figure 3: Neural Network Model for Fruit Classification

Once the networks have been created, the training process was performed to allow the network learns to identify the particular output based on the given input data. The training process used training data to learn the pattern or relationship between the input and output data. The training program was repeated until the criterion was met or converged. The result from the training process revealed the performance of the network. The performance of the NN model was evaluated based on the correlation coefficient (R) [25]. The correlation coefficient, R was calculated to show the strengths of linear relationship between the network outputs and the targets. The value of R was ranged between -1 and 1 where the value of 1 indicates that there is perfect positive linear relationship between the predicted outputs and the targets. The correlation coefficient value can also be represented in a graphical form as illustrated in Figure 4.

The result of the training data above shows a good fit where the value of R is 0.97795 which is close to 1. This means the predicted values produced by the network were almost equal to the target output except for a few data points.

Once the network was trained with a large number of input patterns for desired outputs, it was able to recognize similarities for a new input data and produced a predicted output. The testing process was conducted to measure the robustness of the model and its ability to generalize on different sets of data. In this phase, a new set of 100 jatropha fruit images with four different categories were used. The new samples were appointed as testing data to measure the performance of NN model in classifying jatropha fruit based on its surface colour.

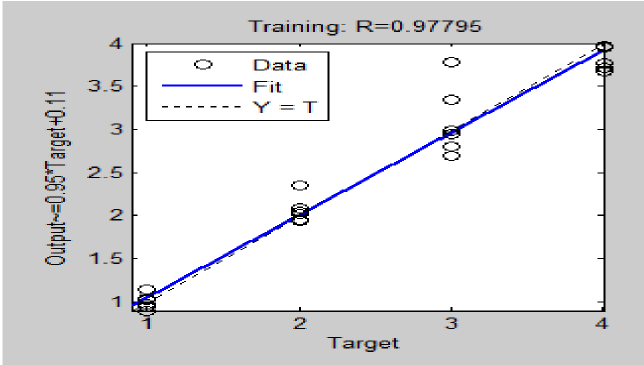

Figure 4: Correlation Coefficient (R) on Training Data

IV. Experimental Results

In this section, the classification results using NN methods are presented. The fruit classification performance was measured based on misclassification rates and classification accuracy. Misclassification rate refers to the number of images that were missing from the correct cluster. The classification accuracy which was represented in percentage was calculated based on the number of images that were classified correctly into the specific cluster. Results in Table 2 present the misclassification rate and classification accuracy produced by NN model.

Table 2
Misclassification Rate and Classification Accuracy for Neural Network Model

Category	Misclassification Rate	Classification Accuracy (%)
Green	0	100
Yellow	2	92
Yellowish-brown	2	92
Black	2	92

As shown in the table, the classification result obtained by NN model is good where the classification accuracy for each category of jatropha fruit is significantly high. As shown in the table, NN model produced 100% correct classification for green and 92% for yellow, yellowish-brown and black. With the 100% accuracy, it indicates that NN is able to classify all the green images very well even though the objects were exposed to natural illumination. For yellow and yellowish-brown objects, NN model also shows better performance where it is able to achieved classification accuracy of 92% for both categories. The results show that the developed NN model has the ability to classify jatropha fruit into four categories with high accuracy rate. These results signify that NN model is able to discriminate objects accurately based on colour elements of the investigated objects.

V. Conclusion

An automatic classification method offers high speed and accurate classification by using the image processing techniques. In this research, an NN model was developed to classify jatropha fruit based on its surface colour. The classification results demonstrate that NN model is a good technique because it has successfully achieved high accuracy rate. The main contribution to the success of NN model is its ability to learn and train the network by mapping their inputs and outputs and finally produced particular patterns in the network. In addition, NN approach is able to classify data even though there is no linear relationship between the input and output values. With the network configuration of 6-7-4, the NN model is robust and works very well even though the objects of interest were exposed to the natural illumination.

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