MODEL FOR PREDICTING AND CLASSIFYING DURIAN FRUIT BASED ON DEFECTS USING NEURAL NETWORK

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Abstract: This study was aimed to develop the model to predict the defect durians from the wholesome ones, based on its physical characteristics by using the neural network. The mass, volume, and acoustic characteristics were fed into the model as the inputs, which provided the classifications of defect fruits from the wholesome ones as the output. Data training were tested to models of neural network with various nodes in the hidden layer, i.e., 4, 6, and 8 nodes. The results recommended the use of 4 nodes in the hidden layer that would provide the highest accuracy of 81.8–84.8% in classifying the wholesome durian and 88.2–94.1% in classifying the defect fruits.

Keywords: neural network, durian, defects, mass, volume, zero moment power

I. INTRODUCTION

Durian is a specific tropical fruit widely known, and nicknamed as “King of Tropical Fruit”. It comes from the plant of *Durio zibethinus*, Murr. Indonesia, so far, has not exported a lot of durian compared to Thailand. Subadrabandhu *et al.* (1991) reported that Thailand exported durian more than 11,000 tons to various countries in Asia, America, and Europe every year. The durian production in Indonesia was 170,871 tons durian in 1995 increasing to 406,146 tons in 1998, however, the export was only 53,767 kg in 1990 and 13,794 kg in 1998. This was due to various factors, among of them were the quality inconsistency and rough post harvest handling.

One of the greater problem commonly faced by the consumers was to select the fruits based on their defects without peeling the skin. Until now, the determination of the fruit contents and defects have been done by extraction method or destructive method where by this way, the durian has to be opened up. Ultrasonic wave can penetrate through high density materials where the acoustic characters, namely the sound velocity and the absorption coefficient are able to show the quality contents and the defect level inside the fruits (Budiastra *et al.*, 1999). Other techniques such as the near infrared reflectance (NIR) have been proved to penetrate only 5 mm in depth from a fruit surface (Ikeda *et al.*, 1992), while X-ray can penetrate through the fruit but results in a high cost.

The quality evaluation of fruits and vegetables using the ultrasonic has been reported by some researchers. Cheng and Haugh (1994) detected the hollow heart of potatoes, Mizrach *et al.* (1989, and 1997) applied the method to determine the maturity of mango fruit, and Budiastra *et al.* (1999) investigated the utilisation of the ultrasonic system for internal quality evaluation of durian. Haryanto (2001), found out that the zero moment power, Mo can differentiate the immature durians to the mature ones, by their respective value 5.877 and 2.505. The relationship, so far, has been done by using a linear mathematical model. In reality, it is a complex system because of the continuous change of durian physico-chemical properties. A neural network model that can relate the acoustic character to the physico-chemicals of durian fruit may solve the problem.
Neural network has been long developed (Rosenblatt, 1957), but the application in agriculture started only in 1980s. Studies were carried out by Susanto et al. (2000) applying the neural network in sorting mangoes based on the concentrations of sucrose and malic acid in the fruit measured by near infrared reflectance (NIR). Rejo et al. (2001) developed and validated a neural network model in predicting and classifying the durian fruits based on their maturity and ripeness. The objectives of this study were to develop and to validate a neural network model in predicting and classifying the durian fruits based on their defects and wholesomeness.

2. EXPERIMENTAL

2.1. Material

Material used in this study was durian cultivar Aseupan from the citizenry plantation in Rancamaya, Bogor with the following characteristics: tapering shape, 2512 g in average weight, 16.5 cm in horizontal diameter, 20.2 cm in length, skin in brownish-light green colour, and yellowish-white pulp. The Indonesian national standard (SNI, 1997) stated that the durian was a short-age type which would fully-matured in 120-135 days after the peak blossom. In this study, the fruits were classified into the following groups: immature (117 days after peak blossom), fully mature (120 days after peak blossom), ripe (stored for 2 days after harvest), and overripe (stored for 4 days after harvest).

2.2. Procedures

The experimental apparatus for measuring the transmission of ultrasonic wave in durian fruits was set up according to Budiastra et al. (1999) as described in Fig. 1. A transducer of 50 kHz was used for measuring the characteristics of durian fruit. The durian fruits were placed between the transmitter and the receiver transducers which had been applied by the silicon grease to enhance the coupling effect. The pulse from the ultrasonic tester $T_{out}$ was sent to the transmitter transducer $T$. After propagating inside the durian fruit, the ultrasonic wave was detected by the receiver transducer $R$ and then was sent to the ultrasonic tester $R_{in}$. The signal from the ultrasonic tester $R_{out}$ was observed by the analog oscilloscope and digitized in the digital oscilloscope. The signal stored in the digital oscilloscope was then transferred to the PC computer through the interface PC Lab Card for further processing and analysis. After the acoustic measurement, the mass, and volume were determined, and then each durian fruit was opened up and subjected to the physico-chemical analysis covering the water content, total soluble solid, total sugar, firmness and total acid. The results of chemical analysis would not be discussed in this paper.

The neural network model used the multi layer perceptron with three inputs, mass, volume and the acoustic characteristic, i.e., $M_o$ the zero moment power (Fig. 2). Two outputs were observed, namely, wholesome and defect fruits. Data used for training the model was 132 pairs, and for the validation was 67. The simulation was carried out in various number of nodes in the hidden layer: 4, 6, and 8 using 1000 and 5000 iterations.
3. RESULTS AND DISCUSSION

3.1. Relationship of Acoustic and Physical Characteristics

Fig. 3 presented the relationship of the fruit physical and acoustic natures resulted from the experiments. The average of Mo and physical characteristics of wholesome durian fruit classified by its maturity and ripeness.

The mass value decreased from 1.873 kg for the defect immature fruit to 1.760 kg for the defect overripe. The fruit volume decreased from 1924.58 cm$^3$ at the defect fully mature state to 1801.67 cm$^3$ for the defect overripe state. Meanwhile, the Mo value was down from 0.34 for the defects-immature fruit to 0.03 for the defect overripe (Fig. 4).

On the other hand, the mass of the wholesome durian experienced sharper decrease from 1.887 kg at the immature state to 1.649 kg at the overripe state. The volume of wholesome durian remained about the same after reaching the fully mature state. The zero moment power for the wholesome durian had a higher value compared to the defect ones, i.e., 0.78 for the immature to 0.12 for the overripe (Fig. 3).

Fig. 5. Mo development in wholesome durian.

Fig. 6. Mo development in defect durian.

Fig. 7. Changes of specific density in wholesome durian.

Fig. 8. Changes of specific density in defect durian.
Fig. 5 and 6 illustrated the zero moment power for the wholesome fruits compared to the defect ones at various maturity and ripeness states. The two curves showed exponential functions with different slopes indicating that the zero moment power might be useful as one of the input parameters to differentiate the defect fruits from the wholesome ones.

Fig. 7 and 8 presented the changes of the specific density, mass over volume, for the wholesome durian fruits compared to the defect ones at various maturity and ripeness states. The linear regression of the two functions indicated different slopes suggesting that the mass and volume could be used as input parameters.

3.2. Neural Network Simulation

3.2.1. Training

The neural network training was carried out using 66 training data pairs and various nodes 4, 6, and 8 in the hidden layer. One thousand and five thousand iterations were applied.

![RMSE by various nodes at 1000 and 5000 iterations.](image)

The results indicated that the Root Mean Square Error (RMSE) of 5000 iterations at all nodes better than of 1000 iterations. The RMSE value for predicting the defects ranged from 0.009611 to 0.004408 for 1000 iterations, and from 0.008543 to 0.003802 for 5000 iterations. The results suggested that the training model using 4, 6, and 8 nodes in the hidden layer with 1000 and 5000 iterations was sufficient.

3.2.2. Validation

Validation was carried out by inputting weights obtained from training and 67 data pairs.

![Validation value at various model hidden layer nodes and iterations.](image)

The results presented in Table 1 and Fig. 10 indicated that the accuracy reached 61.76 – 94.11% in classifying the wholesome and defect fruits at all nodes 4, 6, and 8, and both iterations 1000 and 5000. The classification of the wholesome durian gave the highest error at 24.24% error using 8 nodes and 1000 iterations. While the classification of the defect durian gave the highest error at 38.24% using 6 nodes and 1000 iterations.

The best results were obtained when using 4 nodes and 5000 iterations at the accuracy of 84.8% for the wholesome durian and 94.1% for the defect durian.

4. CONCLUSIONS AND RECOMMENDATIONS

1. Mass, volume, and ultrasound transmissibility (Mo) decreased sharper with the increasing of maturity and ripeness of defect durian compared to the wholesome durian.

2. The neural network model can predict the defects of durian fruit. It provided 84.8% accuracy in predicting the wholesome fruits, and 94.1% accuracy in predicting the defect ones at 4 nodes of model hidden layer and 5000 iterations.

3. It is recommended that the relationship of the zero moment power with the physicochemical characteristics of the durian pulp is established, and will be accommodated in the neural network model.

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<tr>
<th>Classifica-</th>
<th>nodes</th>
<th>1000 Iterations</th>
<th>5000 Iterations</th>
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<td>4</td>
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<td>8</td>
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<tr>
<td>Wholesome</td>
<td>81.81</td>
<td>90.90</td>
<td>75.76</td>
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<td>Defects</td>
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<th>Validation value (%)</th>
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<tr>
<td>Defects</td>
<td>81.81</td>
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![Graph showing validation values for classifying durian.](image)
REFERENCES


