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DEVELOPMENT OF CHILLI GROWTH CONTROL SYSTEM USING AN ARTIFICIAL NEURAL NETWORK

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Abstract: Chilly plant growth rate depends on availability of water and nutrients on growth media. Shortage of the water and nutrients on growth media may cause the growth rate of chilli become slower, smaller leaf area, and worse chilli taste. However, overdoses of the water and nutrients also will cause the cost production become more expensive. The amount of water and fertilizer, which have to provide during the chilli plant growth, are depends on the plant conditions. The neural network was used to determine the amount of water and fertilizer based on the plant conditions. The plant conditions were obtained by analysing the image of the plant. The results shows that the neural network predicted well the amount of supplied water and fertilizer.

Keywords: neural network, chilli growth, chilli plant, image processing, growth

1. INTRODUCTION

Chilly plant growth rate depends on availability of water and nutrients on growth media. Shortage of the water and nutrients on growth media may cause the growth rate of chilli become slower, smaller leaf area, and worse chilli taste. However, overdoses of the water and nutrients also will cause the cost production become more expensive. Development of leaf area, weight, dry weight and stem length depends on the concentration of O_2 on the nutrient (Yoshida *et al.*, 1996). Development of fruits and stem length of tomato plant was depends on water availability on the root zone.

The relationships between the numbers of supplied water and nutrients and plant characteristics should be investigated. From these relationships, optimum number of supplied water and fertilizer can be determined. Image processing technology can be used on non-destructive detecting of plant condition. Information from the image processing can be used to control the apparatus. The integrating of image processing technology and apparatus is called a machine vision (Jain *et al.*, 1995). Measurement of plant growth rate using non-destructive method has been done (Shimizu and Yamazaki, 1995). Feedback control concept for plant growth based on plant responses is called speaking plant approach (Hashimoto *et al.*, 1985). Artificial neural network (ANN) models have shown an increased power over statistical methods when solving non-linear problems. The ANN has been used for analyzing the behaviours of heat transfer inside the plant culture vessel (Suroso *et al.*, 1995, 1996b, 1997) and for determination of coefficient heat transfer over the plant culture vessel (Suroso *et al.*, 1996a). The ANN also has been applied for optimizing the cow feeding management. Combination of ANN of speaking plant approach has been applied in monitoring of lettuce growth inside a phytotron (Murase *et al.*, 1997.

The plant characteristics can be used as parameters to optimize the number of water and nutrient to the chilli plant.

The objectives of this study are 1) to study the relationship between number supplied water and nutrient to chilli plant with their image parameters, 2) to develop a computer program to optimizing the supplied water and nutrient for chilli plant growth, 3) to design the plant growth control system based on the developed program.

2. METHODOLOGY

2.1. Relationship between number supplied water and nutrient to chilli plant with their image parameters

The chilli plants were grown in greenhouse. Determination the relationship between image parameters of chilli plants with provide water and nutrient solution was done by taking the images of chilly plant at three levels of water supply and leaf fertilizer (Table 1).

Table 1 Number of supplied water and fertilizer

Level	Water (mm/plant/day)	Fertilizer (mm/plant/4 days)
1	250	0.55
2	500	1.10
3	750	2.65

The chilli plant images were captured using video camera, which was connected to a computer. The captured images were saved at the hard disk of the computer. The chilli images were captured every 4 days. The images then were processed using the developed image processing program. The outputs from this program were height, length, perimeter, area, perimeter and values of RGB (Fig. 1). The data were collected for 60 days.

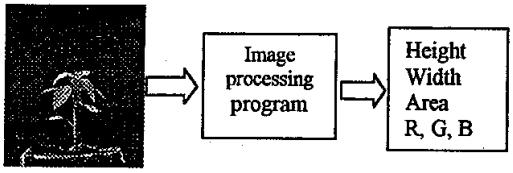

Fig. 1. Chilli plant image processing

2.2. Development of an artificial neural network to predict the supplied water and fertilizer

The relationship between parameter images and age of plant with the amount supplied water and fertilizer was modeled using an artificial neural network. The developed artificial neural network to predict the amount supplied water and fertilizer was inversion of the chilli image processing. The neural network consists of one input layer, one hidden layer and one output layer. The inputs to the neural network image parameters of chilli plant (height, width, area, R, G, B) and ages of the chilli plant. The outputs from the neural network were amount of supplied water and fertilizer. The structure of the neural network was shown in Fig. 2. The neural network was trained by back propagation method. The training data was obtained from the previous experiment.

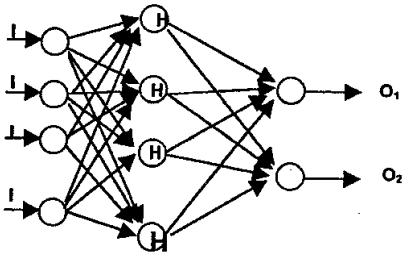

Fig. 2. The structure of the neural network

2.3. Determination amount of water and fertilizer during the growth of chilli plant

The amount of water and fertilizer to the chilli plant was determined based on amount of supplied water and fertilizer, which was calculated by the neural network. The amount of water and fertilizer were calculated using these equations

$$W = 750 - PW \quad (1)$$

$$F = 2.65 - PF \quad (2)$$

Where:

W = amount of water, mm
F = amount of fertilizer, mm
PW = amount of supplied water calculated by the neural network, mm
PF = amount of supplied water calculated by the neural network, mm

The values of W and F were used as inputs to the controller to activate the water and fertilizer pumps. The amount water and fertilizer depends on the duration of water and fertilizer pumps in the active conditions.

3. RESULTS AND DISCUSSION

3.1. Image of chilli plant

The captured images of chilli were process using developed image processing program. The outputs from this program were height, length, perimeter,

area, perimeter and values of RGB. Fig. 3 shows images of chilli plant before and after processing.

Fig. 3. Images of chilli plant before and after processing

3.2. Neural Network Training

The pairs data obtained from the image processing were used as a training data for the neural network. The neural network was trained by 87 data pairs. The validation was done using 43 data pairs. Fig. 4 and 5 show the validation for supplied water and fertilizer.

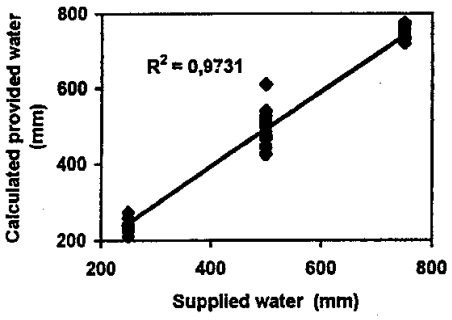

Fig. 4. Validation results for supplied water

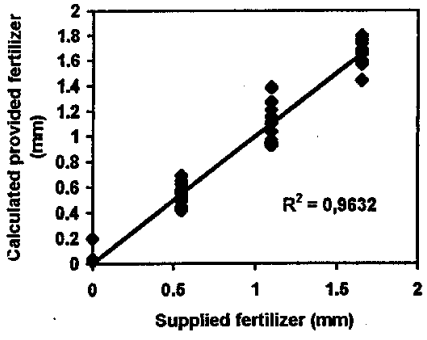

Fig. 5. Validation results for supplied fertilizer

The results show that neural network predicted well the amount of supplied water and fertilizer of chilli plant. The R^2 of the water and fertilizer were 0.9731 and 0.9632, respectively. The supplied water and fertilizer in the next period were calculated based on the predicted water and fertilizer by the neural network by Equations 1 and 2. The amount of water and fertilizer supplied to chilli plant will appropriate, as it's required.

3.3. Water and fertilizer pumping system performances

The amount of water and fertilizer were regulated by change the duration of activating the pumps. Fig. 6 and 7 show the relationship between the duration of activating the pumps and amount of water and fertilizer, respectively. The relationship between providing water and fertilizer with duration of activating pumps were linear with R^2 = 0.8949 and R^2= 0.8708, respectively.

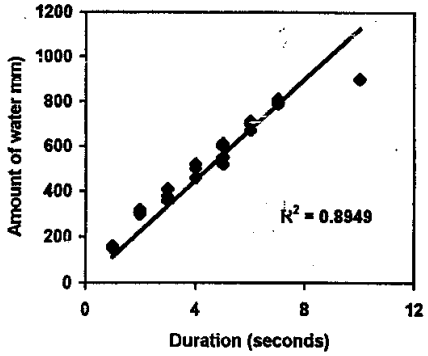

Fig. 6. Relationship between duration and amount of water (mm)

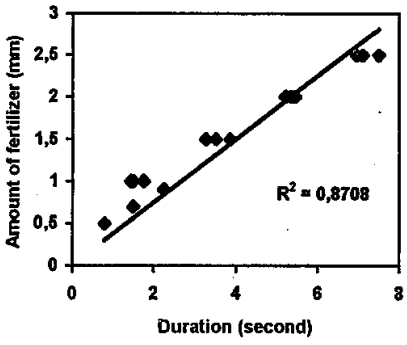

Fig. 6. Relationship between duration and amount of fertilizer (mm)

4. CONCLUSSIONS

1. The neural network predicted the supplied water and fertilizer to chilli plant based on its image parameter.

2. The system demonstrated that the supplied water and fertilizer to the chilli plant can be regulated based its conditions.

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