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Image Processing by Artificial Neural Networks for Stress Diagnosis of Tomato

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Abstract: The present study aimed to diagnose the hanging of the stress to the plant by using images. The position where the influence of the stress appears first was a flower. Shape changes into the flower that receives the stress. Therefore, it was assumed that the stress condition of the plant can be diagnosed from the morphological characteristics such as a shape of the flower. The substantial change appears in the number of sheets of the petal, the number of stigma, and the size of the flower. An image diagnosis system for detecting the strength of the stress occurred in the plant was developed using an artificial neural networks.

Keywords: Image analysis, artificial neural networks, tomato cultivation, stress diagnosis.

1. INTRODUCTION

In recent years, many researches on the application of high-tech to agricultural production systems are actively performed in Japan (Hatou et al., 2009). We have developed a cultivation support system for controlling the environmental factors around the plant while diagnosing the growth status. The concept that controls and manages the environment for cultivation optimally based on the diagnosis of the growth status of the plant is called a 'Speaking Plant Approach (SPA)' (Hashimoto et al., 1985). Some researchers have developed expert systems that supports the decision of the concentration of the nutrient solution in tomato water cultivation (Hatou et al., 1990, Morimoto et al., 1996), that diagnoses the sickness and the harmful insect of the mandarin orange (Hatou et al., 1988) and that diagnose the breakdown of the measuring instrument from the unexpected value of the measurement data (Hatou et al., 1991).

When inputting the data such as answers to questions to the expert system, such data might be often subjective. The difference is caused in the answer for that. Therefore, it is important to exclude the subjectivity as much as possible in order to obtain the steady diagnosis for automation of the cultivation process. Moreover, because the inspection object becomes huge, the automation becomes indispensable in the system that mass-produces it like the plant factory.

In the present study, an active tomato to grow was targeted at the plant factory. The total of the flower that blooms at a time is 200,000 flowers/ha or more at the plant factory. The upper part of the growth point is usually sensitive and it is markedly affected by sunlight and the water stress. Two or more the influences appear in the shape of the flower. These morphological features can be diagnosed based on pattern recognition techniques using neural networks. Consequently, because it was understood that the diagnosis that uses the anther was effective now, it reports to here.

2. TRANSFORMATION OF FLOWER BY STRESS

In the plant factory, hydroponics is well used as a general cultivation method. In hydroponics, the influence such as wilting of the leaf appears in the influence of the water stress that the amount of the water supply with high concentration of the nutrient solution originates in causes such as few. The water stress affects a big influence in the growth point of the plant with which the floral bud is formed.

As a result, the following symptoms appear in the flower.

a) The number of sheets of the petal increases.

b) The shape of stigma and anther cone becomes an oval.

c) The flower becomes large, and the diameter in the root of the calyx becomes large.

2.1 Morphological characteristics in petal

Comparing the morphological feature between the normal and abnormal flowers under stress condition, a significant difference can be observed in the number of petals (Fig. 1). The number of petals of a normal flower is 6 or 7 pieces. The petal number of the abnormal flower is more than that of the normal one. Moreover, the petal of the normal flower forms a circle around the stigma and anther cone. However, it centers on stigma and the transformed flower is done up and down for two minutes. We have a possibility to diagnosis the stress condition of the plant from the shape of the flower because there is a clear difference in the shape.

(a) Normal Flower (b) Abnormal flower

Fig. 1. Examples of the abnormal flower that the number of sheets of petal increases with stress and the normal flower.

2.2 Morphological characteristics in stigma and anther cone

The pistil of a normal flower is only one, and the anther cone is arranged in the circle (Fig.2(a)). Two or more stigmas are observed when the plant suffered from the stress (Fig.2(b)). Anther cone looks like an oval or a fat line. Therefore, it is enable to diagnose the stress condition from the shape because there is a visible change in shape.

(a) Normal flower (b) Abnormal flowers

Fig. 2. Morphological characteristics for the shape of stigma and anther cone.

Fig. 3. Example of size differential of normal flower and abnormal flower.

2.3 Morphological characteristics in size of flower and thickness of pedicel

The flower suffered from the stress is larger than a usual flower. Pedicel tends to thicken along with it (Fig. 3). In Fig.3, a normal flower is shown in red circle and the flower that suffers from the stress is shown in blue circle.

However, because the size judgment was now a difficult task under the present system, mounting by the present stage was put off.

3. PRE-PROCESSING OF DIAGNOSTIC IMAGING

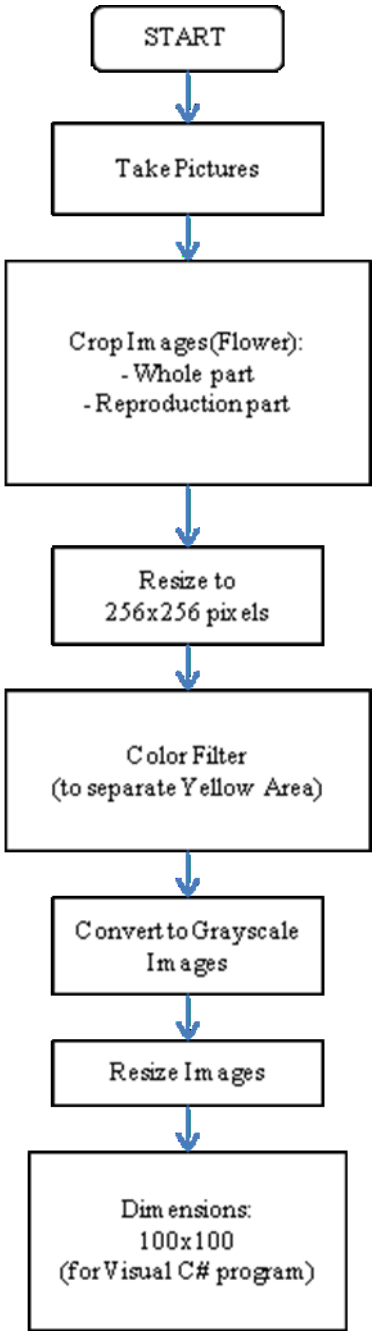
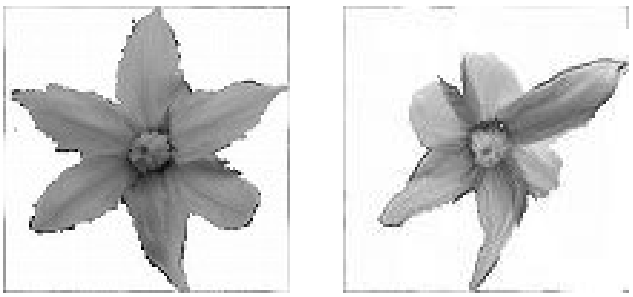


Fig. 4. Flowchart of pre-processing of diagnostic imaging.

The images of two sizes that were appropriate for each diagnosis of the whole (for petal) and reproduction (for stigma and anther cone) were made. It introduces a part of the sample of the result of the picture processing, and it explains the problem.

3.1 Teaching signal of petal image

It might seem that it lacks like (b) though Fig. 5 is a processing image of the flower viewed from the front. When it has rolled it in the other side the petal ahead as shown in Fig. 6, this is seen. As for the petal rolls also, there is a difference in shape by the season and the cultivation method. Therefore, it is necessary to correspond in the diagnostic system.



(a) (b)

Fig. 5. Processing result of normal flower.

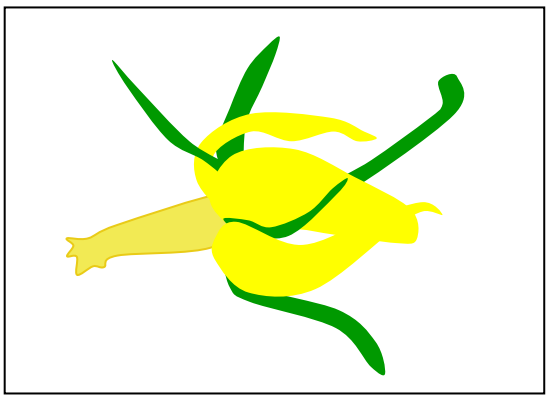


Fig. 6. Petal head rolling in back side.

One example of the processing result of the flower that receives the stress to Fig. 7 is shown. Shape looks like these two images. Then, it was assumed that the image that cut leafing ahead to distinguish these was used as a teacher signal.

Fig. 7. Example of the processing result of stressed flower.

3.2. Teaching signal of stigma and anther cone

There are two stigmas or more the maximum feature. As the influence, the shape of anther cone is not a column and becomes it. It might open greatly anther cone ahead (Fig. 8). These features cannot be missed. Therefore, these data was used as a teacher signal.

(a) (b) (c)

Fig. 8. Examples of stigma and anther cone.

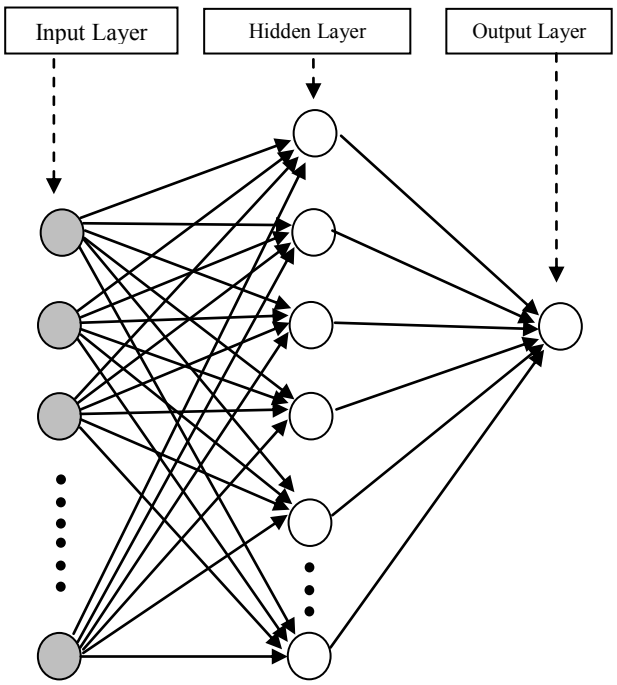


Fig. 9. A three layered neural network for diagnosis.

4. ARTIFICIAL NEURAL NETWORK

The three layered neural network was used for the recognition of the image. Back propagation was used for the learning of the teaching signal (Fig. 9).

Because the image of the flower suffered from the stress was few in this experiment, the teaching signal should be reduced as much as possible. Numbers of hidden layer and epoch were changed in the experiment and the accuracy rate was obtained. Fig. 10 shows the result of diagnosing the shape of the petal by using the neural networks.

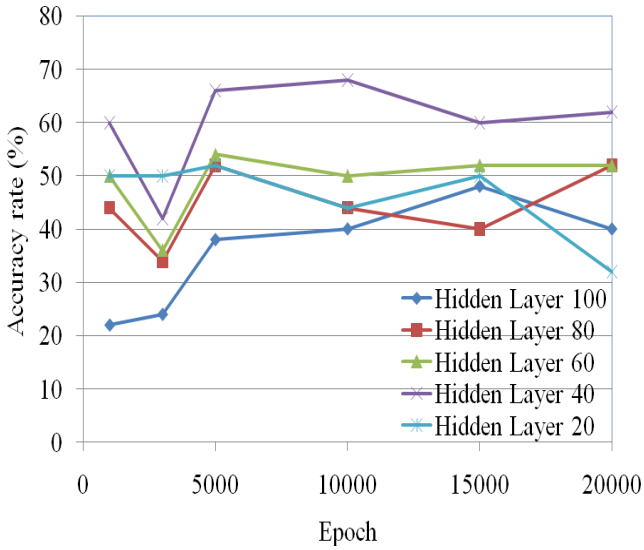


Fig. 10. Relationships between epoch and the estimated accuracy (%) of whole flowers.

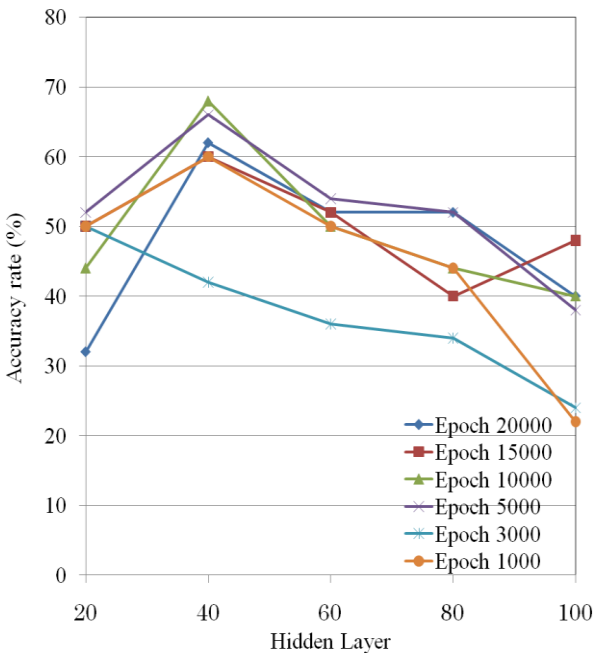


Fig. 11 Relationships between the neuron number in the hidden layer and the estimated accuracy (%) of whole flowers.

When numbers of hidden layer was 40 and epoch was 10,000, we get best result. The result has not improved though numbers of hidden Layers is increased more than this. It was a comparable result though epoch was increased.

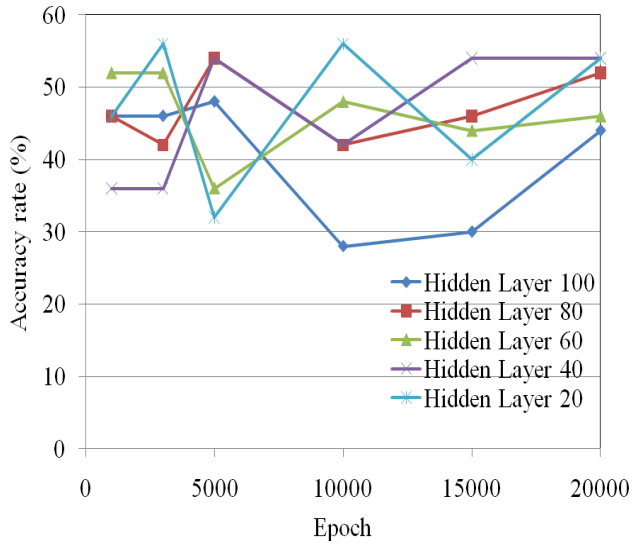


Fig. 12. Relationships between epoch and the estimated accuracy (%) of stigma and anther cone.

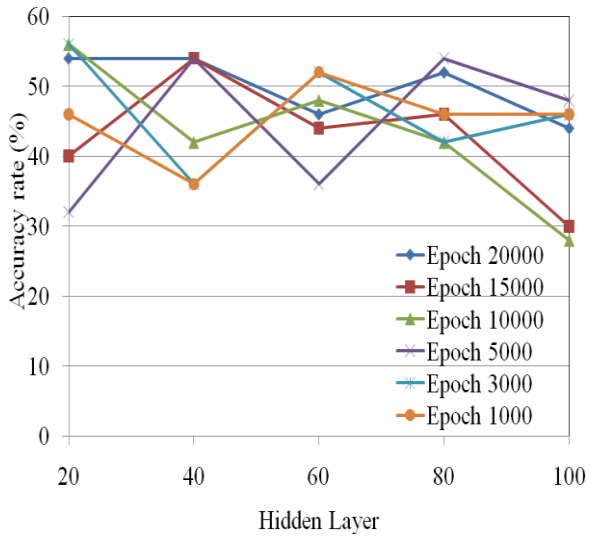


Fig. 11 Relationships between the neuron numbers in the hidden layer and the estimated accuracy of stigma and anther cone.

The estimated accuracy of the diagnosis for stigma and anther cone was low. Accuracy is thought that the petal and the identification of the surrounding are difficult anther cone as a low reason.

6. CONCLUSIONS

It was found that the three layered neural networks used here allowed the stressed flower to be successfully found. However, it is not accomplished all the range, but within a range that the influence goes out. It is thought that the examination of the method of selecting the development of the method of pre-processing a new image and the teaching data is necessary to solve this problem. I want to aim it using an actual plant factory in the future.

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