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EVALUATION OF FLOWER BY NEURAL NETWORK

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ABSTRACT

The color image of the rose was segmented by the cluster analysis on the color space into the characteristic sub-regions, the degree of bloom of the flower was represented numerically base on the segmented image and judged by the artificial neural network system whose input variables were the characteristic regions. Judgment by neural system were compared with that of the farmers and it was found that degree of agreement were fairly good.

Key Words : Neural Network, Backpropagation, Blooming, Flower, Color Image, Cluster Analysis

INTRODUCTION

The resent rapid growth of the flower market increases the production acreage of the individual flower growing farmer, therefore it becomes serious problem that he is short of workers. In such farms, he has already mechanized the fertilizing, pest control and sprinkling, but the sorting and grading the flower at and after harvest are almost performed by manual inspection even now because the shape and color of the flower are complicated and the decision criteria of them is very sensitive. Hence, mechanization is necessary in harvesting and sorting process in the flower industry. In this research, the artificial neural network system were simulated by the computer to judge the degree of bloom of the rose by use of the color image data. The results of judgement by the neural system were compared with the farmers' judgement.

EXPERIMENTAL APPARATUS

The color image data of the flower was collected by the color camera(Ikegami ITC730A) and the Nexus 6800 system and processed by the work station(SPARKstation 2, SUN microsystems). The flower laid on the dim black paper was illuminated by the four commercial fluorescent lamps(National FL15EX-N, Matsushita). The number of pixels of the image was 512×480 and the intensity levels of RGB images were 8 bits(256 levels), respectively.

EXPERIMENTAL METHOD

a) Experimental Materials The flower of rose was used for the experiment. The variety of rose was *Rote Rose* and the color of its petal was from 5R to 10RP in Munsell color system. The stage of bloom of the flower is usually divided into six categories denoted as from phase one to phase six. The blooming phase one represents the bud and phase six is out of bloom. The blooming phases of 2, 3 and 4 are usually considered to be suitable for selling at the market according to the season. In this experiment, we used the flowers judged to be the phases of 2, 3 and 4 by the trained farmers.

b) Experimental Procedure The computational procedure for judging the degree of bloom consisted of the following three stages.

STAGE 1 ; Flower Image Segmentation The flower image was segmented into the characteristic regions. The image segmentation can be performed by various methods such as the thresholding. In this research, the cluster analysis on the CIE 1976 $L^*a^*b^*$ color space was used to discriminate the delicate color of the petal Hotta *et al*,(1990).

STAGE 2 ; Shape Feature Extraction The feature of the petal's shape was extracted numerically from the characteristic region. When the flowers are sorted in the flower farm, the information on the shape as well as the color have the important role. Because the man processes these information to make a decision, the data for computer sorting should contain the information on the shape as well as the color of the petal.

STAGE 3 ; Judgment of Blooming Degree by Neural Network The neural network system with four layers learned and judged the degree of bloom of the flower with the data obtained in STAGE 2.

In STAGE 1, the color image of the side view of the flower was inputted into the computer and analyzed into the clusters on the $L^*a^*b^*$ color space as follows.

1) The NTSC RGB data of each pixel were transformed to the $L^*a^*b^*$ color space through the CIE 1931 *XYZ* color system and plotted on the $L^*a^*b^*$ color space. Let the vectors representing each pixel plotted on this color space be $\boldsymbol{p}_n$ for n=1,...,512×480.

2) The k representative vectors of each cluster were defined on the $L^*a^*b^*$ color space as the starting values for the cluster analysis and the representative vector of the *m*th cluster is expressed as $\boldsymbol{r}_m$. Although the number of the clusters should be equal theoretically to the number of the regions to be segmented, the expected image segmentation could not be performed when the color of the regions were similar closely to each other. The more the number of the clusters was, the more precisely the delicate difference of color could be detected. In this research, the least number of the clusters was decided to be 12 by trial and error considering the computing time, and these twelve clusters could segment the image into the petal, the recurved petal, the sepal and the background.

3) For one $\boldsymbol{p}_n$, the least color difference between this $\boldsymbol{p}_n$ and the $\boldsymbol{r}_m$ for m=1,2,...,12 was searched and $\boldsymbol{r}_i$ was considered as the vector of the shortest distance from $\boldsymbol{p}_n$. The $\boldsymbol{p}_n$ was assigned to the cluster i. In this research, the

color difference was the Euclidean distance on the $L^*a^*b^*$ space.

4) When the procedure 3) has been performed for all pixels and they has been assigned to any cluster, the new representative point of the cluster was redefined as the center of gravity of the points contained in that cluster.

5) The procedures from 3) to 4) were repeated the prescribed times(20 times in this research).

These procedures relocated the starting representative points from the state shown in **Fig.1**(a) to that in (b).

In order to reduce the number of repetitions required for the cluster analysis, the starting representative points were defined as the estimated centers of gravity of the groups of points. Each group consisted of the pixels plotted on the $L^*a^*b^*$ color space which appeared to present approximately the individual part of the image. The representative points relocated after the cluster analysis were categorized into the following four groups, that is, the points in the region with chroma less than 10 and lower brightness were the black background paper, the points in and near the region from 5BG to 5GY in Munsell color system were the sepal and the region from 7.5R to 10RP was petal and the points of the lower chroma in this region were the recurved petal as in Fig.1(b).

In **Fig. 2**, the original image is shown on the left and the image segmented by the cluster analysis on the right. It is possible to recognize that the image could be segmented correctly into the four regions. The characteristics of the region at each blooming phase are as follows. At the phase 2, the petals were covered almost entirely by the sepals, and at the phase 3, the sepals were opened and the recurved petal could be viewed only from the direction where the most exterior petal were flowering. When we took the image of the flower, this direction were considered as the front view. The rightward and leftward 90° rotations from this position gave the right and left side view of the flower, respectively. The image viewed through 180° rotation was regarded as the opposite side view. At the phase 4, the shape of the flower changed as if the center of gravity of the flower silhouette moved upward and the sepal opened still more. The recurved petal could be viewed from any direction, but its shape depended upon the viewing direction.

In STAGE 2, we provided the data of the shape from the image of the petal extracted through the above mentioned procedure. We tried to detect the shapes of the petal, the recurved petal and the sepal as well as the change of the shape due to progress of bloom by the following manner, that is

1) The center of gravity was determined for the region unifying the petal and sepal of the rose at phase 2, as shown in **Fig. 3(a)**. We determined the ratio *a*:*b*(about 2:1) at which the horizontal line through the center of gravity divided the vertical axis cut off by the top and bottom edges of the flower.

2) For any flower image, we defined the origin which divided the vertical axis between the top and bottom edges at the above mentioned ratio, as shown in Fig. 3(b). This origin divided equally the horizontal width of the petal.

3)The virtual sepal was determined as the region closed by two vertical tangential lines to the right and left sides of the petal, the horizontal line through the highest tip of the sepal(shown in Fig. 3(b) with the broken line) and the bottom line of the sepal. The definition of the sepal in this manner removed the complexity of the sepal's shape and the irregularity of its position.

4) The seventy two lines at the interval of 5° through the origin determined the contour of the flower by intersecting with the outer edges of the petals, the recurved petals and the sepals. In Fig. 3(b), the circle, square and triangle on the line through the origin represent the outer edges of petal, recurved petal and sepal, respectively.

Thus the distances of the edge points from the origin could be determined and each distance was normalized by the maximum distance. When the normalized distances to the edge points of the petal, the recurved petal and the sepal were P_1,R_1 and S_1, respectively, the data at one direction were denoted as (P_1, R_1, S_1).

In STAGE 3, the artificial neural network system learned the data obtained in STAGE 2. This neural system had the four layers, and had 216 units in the input layer, 72 in the first hidden layer, 20 in the second hidden layer and 7 in the output layer, as shown in **Fig. 4**.

1) **Input and Connection** In the input layer, the input signals for the 1st to 72nd units were the shape data $\{P_1, P_2,...,P_{72}\}$ of the petal, for the 73rd to 144th units were the data $\{R_1, R_2,...,R_{72}\}$ of the recurved petal and for the 145th to 216th units were the data $\{S_1,S_2,...,S_{72}\}$ of the sepal. The connections between the units in the input layer and those in the first hidden layer were the local connections in which the neighboring three units in the input layer were connected to one unit in the first hidden layer. All the units in the first and second hidden layers and output layer joined with each other, as shown in Fig. 4.

2) **Output** Because it was supposed that the flower of the phase 2 viewed from all directions might be judged to be the same, but the front, right side, left side and opposite side views in the phase 3 and 4 be the different shape, we designated the degree of bloom(phases 2, 3 and 4) and the direction(the front, right, left and opposite side views) to the first to seventh outputs, respectively. For the phase 2, the output signals judging the viewing direction was fixed to be the front side, that is (1, 0, 0, 0). Such specification of the output layer as this might realize the tolerance to the error due to the scattered data caused by the viewing direction.

3) **Training** The training examples were the data obtained from the images of these four sides of the two flowers for each phase from 2 to 4. The neural system learned with the backpropagation algorithm. The *en bloc* corrective moment method adjusted the connection coefficients and the offset values where the set of training data was presented and the errors were bundled Nakano *et al*, (1989). To prevent the excessive learning, the input data contained the random errors within $\pm 3\%$ of input data. The learning process finished after 2000 to 2500 times repetition for the maximum error of 0.05, and it took about 30 minutes. Although the number of units in the first hidden layer could be determined by the connection from the input layer, there is no theoretical manners to determine the number of the units for the second hidden layer. Thus, we tried to learn for the various numbers of the units in the

second hidden layer and decided to be optimal number when the highest agreement of judgment with the man could be achieved. In general, the more the number of the units in the hidden layer is, the higher the ratio of discrimination is, but this ratio may have a certain maximum value. In this research, the maximum discrimination ratio was accomplished for 20 units, so we specified the number of units in the second hidden layer to be 20.

4) **Judgment** The learned neural system judged the 96 image data. These data consisted of 24 flowers each of which had four images and which were divided equally into three groups of phase 2, 3 and 4. The judgment of the neural system was determined by the output nearest to 1.0 and compared with that of the farmer. The results are shown in **Table 1**.

The agreement ratio of phase 2 was highest, because the shape of the flower of the phase 2 was simple compared with other phases.

CONCLUSIONS

The color image of flower of rose was segmented successfully by the cluster analysis on the $L^*a^*b^*$ color space into three areas, that is petal, recurved petal,sepal and background.

The degree of bloom was described numerically by the segmented areas of the flower and judged with the artificial neural network system.

On the whole, the 82% of the judgment of the neural system agreed with the judgment of man and this result should be improved for the practical application.

The following problems, therefore, should be solved for the practical use of the artificial neural network system.

1) **Computing Time** It took long time for the cluster analysis, that is around one minute, so it will be necessary to develop the high speed image segmentation technique.

2) **Feature Extraction** In order to increase the recognition ability, we should improve the quantitative description of the image data, especially the sepal

should be more accurately characterized.

3) **Training Example** It is very important problem how to select the training examples and how many examples to adopt. Because there may exist the scattering and misjudgment of the example, it is necessary to select the typical training example for any blooming phase. It is said that the number of training example to be presented should be at least five times the number of units in the network Maren *et al*, (1990). Thus, it may be necessary to generate the artificial training example automatically in the computer.

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Table 1 Comparison between Judgment of Neural System and Man

Blooming Phase	Agree with Man	Not Agree with Man	Ratio of Agreement
2	29	3	90.6
3	26	6	81.3
4	24	8	75.0
Total	79	17	82.3

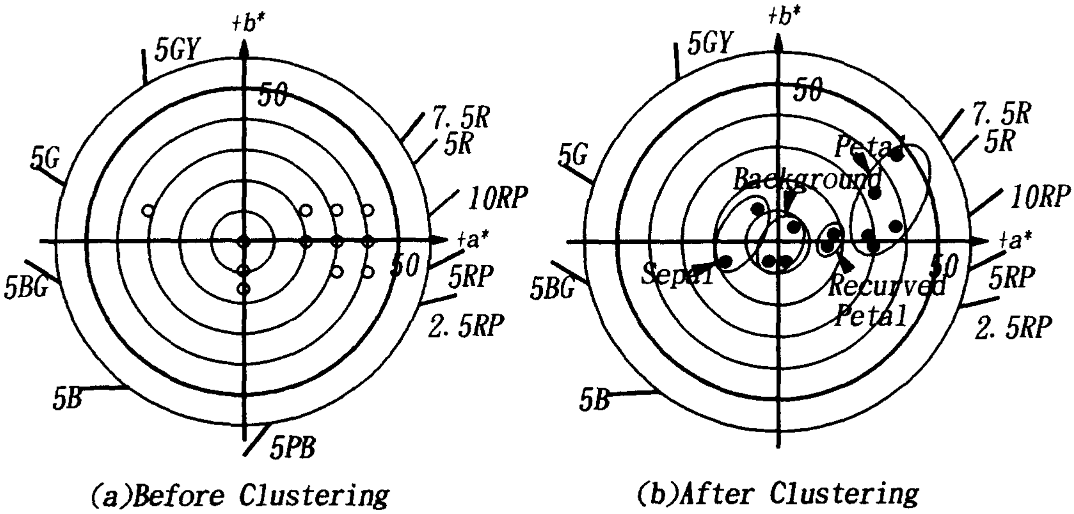

Fig. 1 Location of Representative Points before and after Clustering

Fig. 2 Original Image(Left) and Segmented Image(Right)

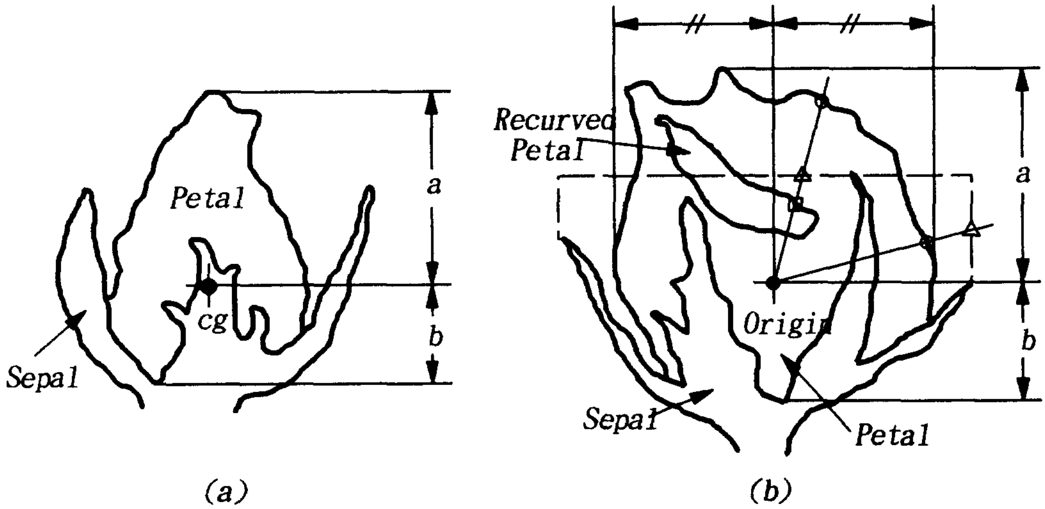

Fig. 3 Determination of Origin and Feature Extraction of Flower Image

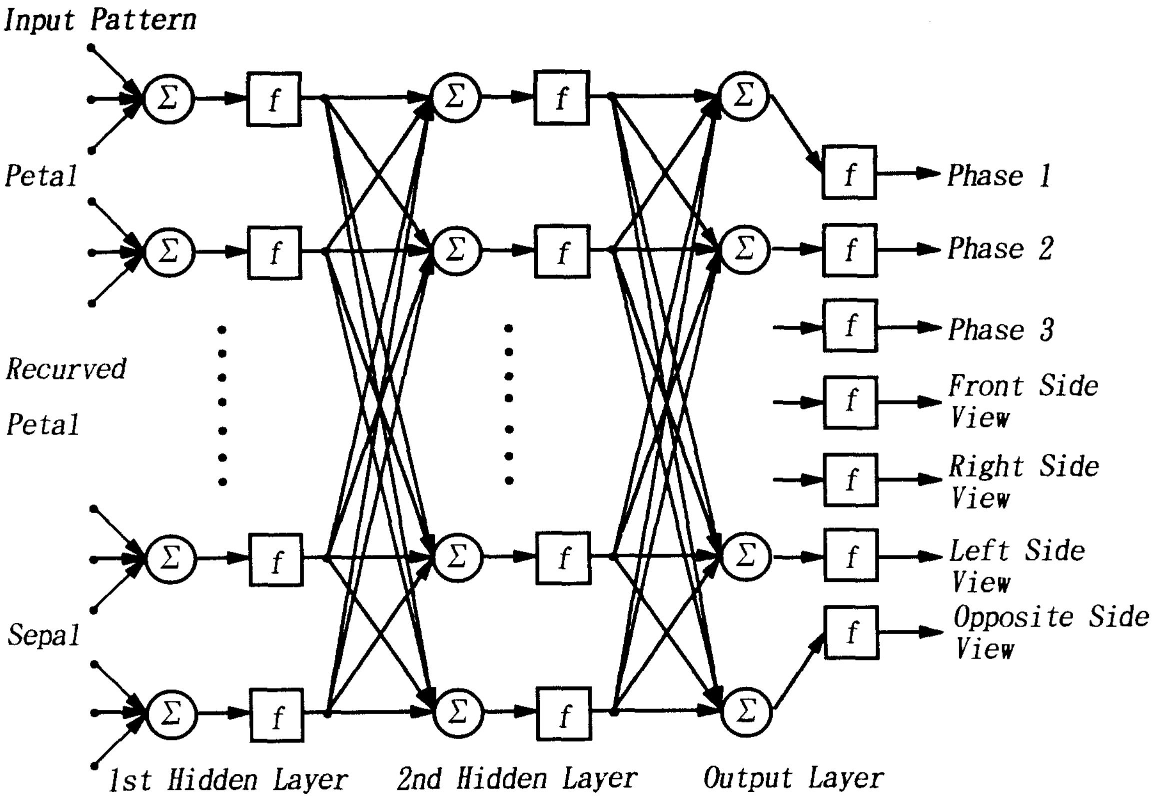

Fig. 4 Structure of Artificial Neural Network System with Four Layers