RESEARCH OF PROMOTION JUDGE SYSTEM USING AN IMAGE IN AGRICULTURE

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ABSTRACT

Color chart area is automatically extracted in image that captured a crop such as fruits with the color chart, and an approximation formula is obtained for the change in feature value of the color indexes. Comparison is made with the color value of the crop area, and the growing degree is assessed according to the correlation.

Using a compact PC equipped with the program, image of fruits is captured, and the output value obtained by the system is compared to the rating by expert.

In the automatic recognition of the color chart out of doors, the complete color indexes is correctly acquired in 22 of 29 images. And indoors, they are correctly acquired in all of 34 images.

In the color value judgment of the Japanese pear, indoors, 32 of 34 images is within 1.0 of the judgment error (compared the value read off by experts), the average error is about 0.5. These results indicate a practicable value.

Keywords: image processing, color chart, crop, growing degree

1. INTRODUCTION

In agriculture, as a slight delay of judgment and wrong adjustment may sometimes have much effect on growth and development, an easy and stable method of judging growing condition is required by using information technology.

For cultivation of rice and fruits, the color charts indicating the growing stage of each farm crops are used to judge their growing condition [1].

Normally, experts observe them using the color chart and read off the growing degree numerically. The method of using a color chart is low cost. On the other hand, if there is no expert, judgment is difficult, and the judging deflection by observers also becomes a problem.
Research of color measurement of the fruits using digital camera has been done [2] [3]. This research is automatic growing degree judgment by color.

The authors are researching of the color correction by the color chart for agricultural crops [4]. And we are also doing research that judges the degree of growth from leaf color [5]. In this study, by comparing the color of the color chart and the crops using the image, it tries to judge the growing degree automatically. If the growing degree can be judged automatically from the images taken by digital cameras, experts would not have to judge its growing degree and there would be no judging deflections by observers. It becomes a system which a farmhouse can use low cost and easily.

2. AUTO EXTRACTION OF COLOR CHART AND INDEXES

2.1 Color chart for agricultural crops

Color observations of rice crops and fruits are performed by using a rice-crop color chart from 'Fujihira Industry Co., Ltd.' with seven color indexes lined up in sideways, and fruits color charts from 'Japan Fruit Growers Cooperative Association' with color indexes of 3-5 lines by 2 rows, respectively (Fig.1).

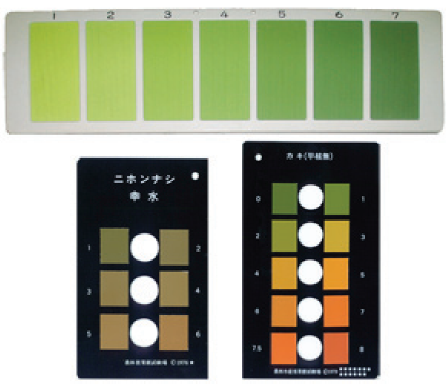

Fig. 1. Example of color chart for agricultural crops: rice (up), Japanese pear (down-left), persimmon (down-right)

Observation of rice crop is performed by two persons. One person holds the chart in a rice crop field, and the other makes an observation at a position 3 meter away from the chart holder. The observer compares the colors of surrounding rice crop field and the color chart, and makes a decision on which color index represents the rice crop color most. While the color chart is labeled with seven integer values, observation value is recorded with a resolution of the order of 0.05 (e.g. 4.25). Observation is performed when direct sunlight is not falling on the field, and the observer stands with his back facing the sun. Make sure that the color chart faces parallel to the observer without tilting upward or downward.

Observation of fruits is performed by a single person. The observer looks the fruits surface through a hole in the center of the chart and makes a decision on the color. In this case as well, direct sunlight to the chart is avoided during observation.

2.2 Extraction of color chart

Hierarchical template matching is performed for automatic-extraction of a color chart.

First, the situation where the color judging is actually performed at the farmhouse was photoed, and the distribution about how a color chart is reflected to images investigated.

Distribution is measured using 88 images (29 fruits, 59 rice) photoed at the farm-field. In case of the fruits, the area rate of color chart is narrow (The difference of the maximum minimum is 3.5 times) and the inclination of the chart is big (the difference of the maximum minimum is 13 degrees). On the other hand, in case of the rice, in the area rate of color chart is wide (5.5 times in the same way), and the inclination is small (7.5 degrees in the same way).

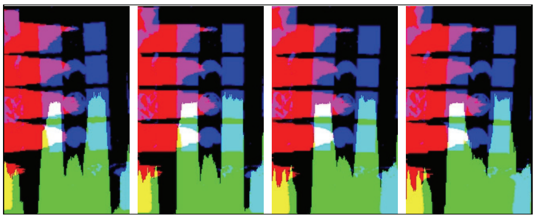

Fig. 2. Rotated image and projection histograms

Fig. 3. Extraction of color chart and color indexes

In case of the fruits, because it has a chart oneself and it judges a color, it is because the chart has often leaned. In case of the rice, it is because the distance doesn't become uniform to judge at two (the person who has a chart at the rice paddy and the observing person).

Based on this result, in case of the fruits, the inclination prepares five template images that added plus-minus 5 degrees and plus-minus 10 degrees. In case of the rice, it makes the hierarchy of the hierarchical template matching 1 paragraph deep and it extract.

2.3 Extraction of color indexes

Next, it extracts color index values from the range of the found color chart.

The extracted color chart has a turn to the direction of the camera and back and forth an inclination. Also, the hole for the peep is open to the center of most charts for the fruits. Therefore, it is difficult to extract color indexes from a pattern.

It follows the conditions that the color in a color chart is mostly located in a line regularly in the same size, and the conditions that the color chart for agricultural crops has the narrow range of the color currently used. Then it extracts a color index value by the following procedure.

(1) It changes RGB into HSV. And it makes binary by the difference of the range with the hue that will be contained in the color index value and the hue of the chart's frame.
(2) It creates the projection histograms (level and vertical) about this image.
(3) It turns from -5.0 to 5.0 degrees with the 1.0 degrees step, and it computes the 1st differential calculus value of the vertical projection histogram, and it seeks a value with the maximum absolute value in it (Fig.2).
(4) In the rotated image, the greatest image of a value is decided to be a representation image.
(5) It calculates a peak with the 1st differential calculus value of the projection histogram. And it demands ameans with the RGB values of the rectangular areas that the range on the peaks of the projection list forms. They are color index values.

2.4 Result of the extraction

It compares the result of the automatic-extracting and a result of being extracted by the manual labor operation to the image from the photoed image.

As a result, the complete color indexes is correctly acquired in 22 of 29 images (75.9%) at the fruits out of doors, the complete color indexes is correctly acquired in

48 of 59 images (81.4%) at the rice out of doors.

Images that failed in the color index extraction are analyzed. There are seven images that had one or two unreadable color indexes out of seven on each chart. These color indexes are unreadable because the frame of color index was partially blocked by rice placed in front. Remaining 4 images fail in the extraction because the chart size captured in the image was smaller than assumed (image captured from too distant a place).

As for fruits, significant backlighting make the color indexes difficult to distinguish even with human eyes in some cases, or a part of color indexes is blocked by fingers that held the chart in other cases.

These problems can be prevented by simple instructions prior to the image capturing.

3. JUDGEMENT OF GROWING DEGREE

Change in the crop color is assessed by the color index value extracted from image. In this study, Japanese pear "Hosui" is selected as a fruits crop for which the growing degree is determined by the fruits color change. Hosui, a cultivar of Japanese pear, is also called red pear and its fruits color significantly changes from green to yellow to brown as the growing degree increases. Therefore, the color change is analyzed by the color index values obtained from a series of images that captured a pear with the color chart.

Changes in green color intensity(G), red color intensity(R) and hue(H) are analyzed as parameters for indicating the growing degree. The hue change show the highest correlation with the growing degree(Fig.5). Therefore, an approximated curve is obtained for the hue change, to be used for the growing degree assessment in which a fruits color value is judged according to the position on the curve.

It judges as follows.
(1) It approximates in the curve in the hue value about seven extracted color indexes (1.0-7.0).
(2) As for the area of the pear in image, it acquires a color. It calculates the average of the hue to the pixels for the pear inner circular area. At this time, the pixels whose brightness is extremely low, and extremely high pixels (shade area and highlight area) are excluded.
(3) It calculates a growing degree by the acquired average and the maturity change function of the pear.

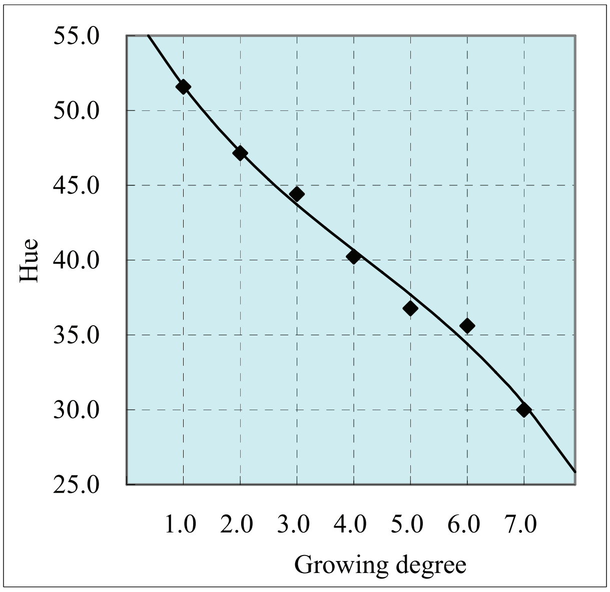

Fig. 5. Color index values and the approximate curve

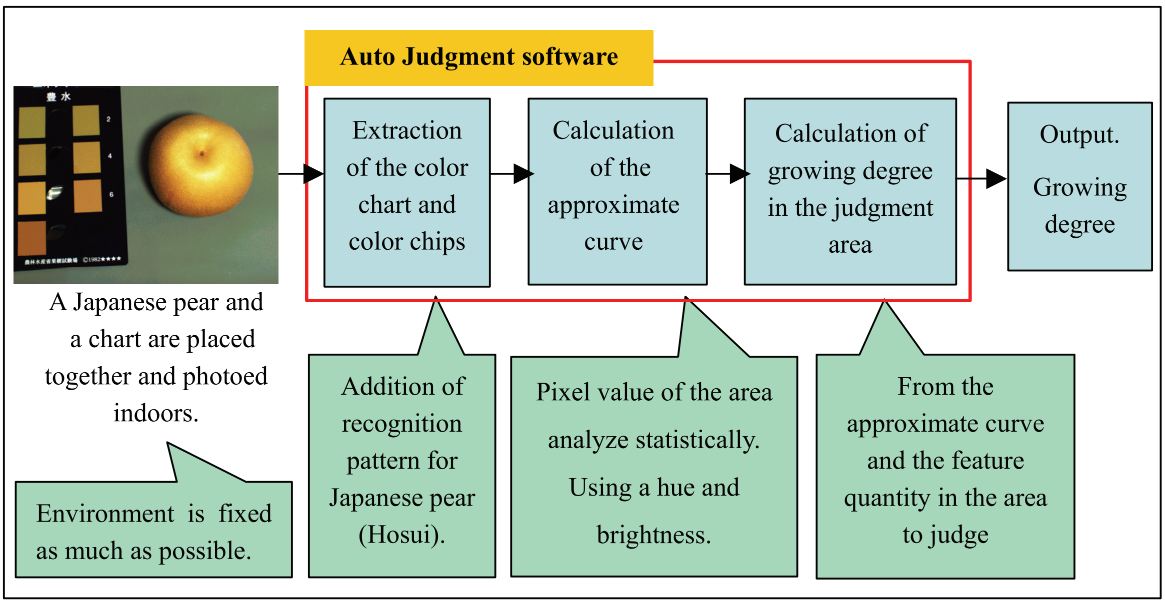

Fig. 4. Flow of judgment

4. EXPERIMENT

4.1 Experimental conditions

Using the developed system, we conduct image capturing of "Hosui" pears at an indoor fruit-sorting facility. Images are captured under fairly uniform incandescent lighting. Each image contains a pear and a color chart placed side by side. The color chart for "Hosui" pear is used. Images of 34 pears from low to high maturity are captured and it analyzes to calculate the maturity color value.

At the same time, the maturity of these pears is rated separately by an expert sorter. The expert sorter judges the maturity in a 14-point rating scale, from 1.0 to 7.0 at 0.5 intervals and >7.0. Maturity color values obtained by our system are compared with the maturity values rated by the expert sorter.

4.2 Experimental result

Compared to the expert's rating, the value difference is not greater than 1.0 in 32 cases, with a mean difference of approximately 0.5. Difference of 0.5 is generally considered to be acceptable, given the variation among sorters, and therefore, the output values obtained by our system are practically feasible.

In both of the two cases in which the difference was greater than 1.0, maturity is low and the system gives higher values compared to the expert's rating. The reason for this may be that the expert judges the maturity of premature pears based on not only the color but also various aspects including texture and appearance of skin surface. Similar tendency is found in other cases with relatively low color values. This tendency will have to be considered in future work.

Fig. 6. Device for experiment

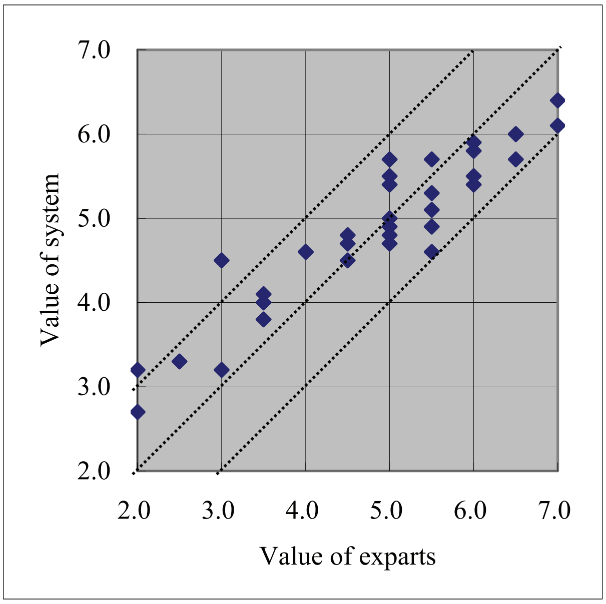

Fig.7. Comparison between the value read off by experts and the value calculated by the system

5. CONCLUSION

The color chart for agricultural crops and its color indexes have been automatically extracted from the image, and it calculated the approximate formula about change of hue. We developed the system that does a judgment the growing degree by these relations than the hue of the crop area. After comparing the values that the rating by expert and the output values obtained by system, the mean difference became about 0.5 indoors about the fruits. These results indicate a practicable value.

In future, consideration will have to be given to feature values other than hue and to an extraction algorithm that is robust against variations in the imaging conditions, so that the assessment can be carried out outdoors.

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