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Final Program and Abstracts

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A Distinction Method for Fruit of Sweet Pepper Using Reflection of LED Light

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Abstract: This paper describes a distinction method for fruit of sweet peppers, which are grown in greenhouse, using reflection of LED light. Distinction for fruit of sweet pepper is necessary for development of picking robot in greenhouse horticulture. We have been manufactured a prototype of picking robot for sweet peppers. This picking robot has an image processing system using a parallel stereovision, a positioning system to the recognized sweet pepper using visual feedback control, and a cutting device. However, the distinction ability is lacking. We proposed a distinction method for fruits of sweet pepper using reflection of LED light. Experiments were carried out in greenhouse. In consequence, it was possible to improve the distinction ability.

Keywords: Picking Robot, Image Processing, Recognition, Visual Feedback Control, Stereovision, Sweet Pepper, Greenhouse.

1. Introduction

In Japan, greenhouse horticulture is flourishing as shown in Fig.1. Greenhouses are covered with vinyl sheets, and keep vegetable from farming enemies such as strong wind, bad weather, harmful insect, and so on. Greenhouse horticulture help agricultural products to grow more efficiently and keeps them high quality because of the controlled circumstance. In recent years, the shortage of farming labor force is getting worse because of impact of the falling birthrate and the aging farmers. For the solution of this problem, some automatic greenhouse horticulture systems have been proposed. They are, for example, automatic temperature control system, automatic watering system, automatic picking system, and so on. Automatic temperature system and automatic watering system have been investigated. Picking robots for eggplant and tomato have been also studied [1][2]. The difficulty of picking robots exists in identification of fruits, cutting systems, moving systems, and so on. Recognition of fruits is newly carried out by image processing using camera. Therefore, the picking robot system for the fruit that has special color such as eggplant and tomato has been investigated. Although sweet pepper is major agricultural produce in greenhouse horticulture, its picking robot has not been studied. Because the color of fruits is almost same of leaves, and recognition of the fruit is difficult.

Fig.1 Photograph of greenhouse

Sweet pepper trees are planted on chins in greenhouse and sweet peppers are growing on trees as shown in Fig.2. Sweet peppers that are within the standard are picked by farmers. The procedure to pick sweet peppers is follows. First farmers look for sweet peppers that meet the standard of its size/shape with their eyes and hands. They cut stems of the selected sweet peppers, and put into the container. The concept of picking robot for sweet pepper is shown in Fig.3. A prototype of picking robot for sweet peppers has been developed [3][4]. The illustration of picking robot is shown in Fig.4 and the photograph of prototype is shown in Fig.5. This robot has an image processing system with a parallel stereovision, a camera positioning system to follow the recognized sweet peppers by visual feedback control, and a cutting device.

Fig. 2 Left: The sweet peppers are grown in greenhouses. Right: The actual method of picking sweet peppers by farmers.

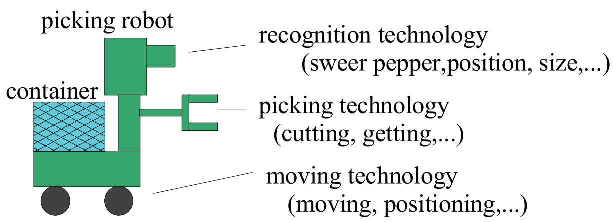


Fig.3 The concept for picking robot

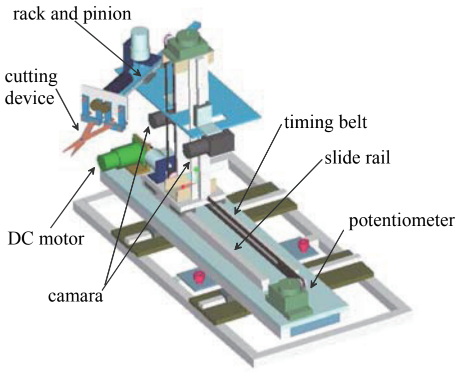


Fig.4 illustration of picking robot

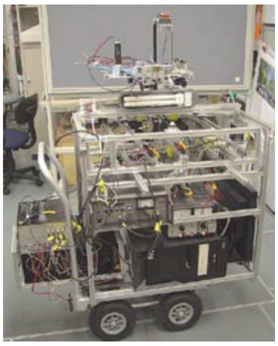


Fig.5 Prototype picking robot

2. Image processing system

The image processing system consists of two color CCD cameras, a capture board, and image processing applications, is shown in Fig.6. Two cameras are placed in parallel. By stereovision of the two cameras, the distance between the camera and the recognized sweet pepper can be measured. In this image processing, the light is important factor for capturing the image of stable brightness. So we used LED light [7]. LED light is installed the CCD camera, as shown in Fig.7. The LED light device is compact and limit the area of lighting to small. By limiting the area of lighting, it is highly possible to that the result of image processing of left camera corresponds with the result of the right camera. The captured image using white LED is shown in Fig.8, and these HSI color specification are shown in Fig.9. When using the white LED, especially the Hue value of fruits is different from the value of leave. Then the fruits of the sweet pepper are recognized by binarization of HSI color specification system with the use of this difference. However only this method, the recognition is unstable in greenhouse. Then we proposed a distinction method for fruits of sweet pepper using reflection of LED light.

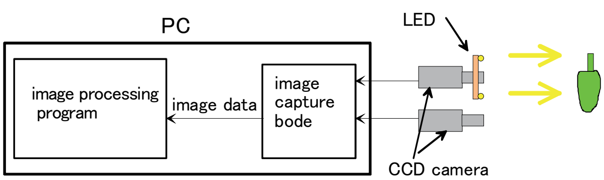


Fig.6 Image processing system

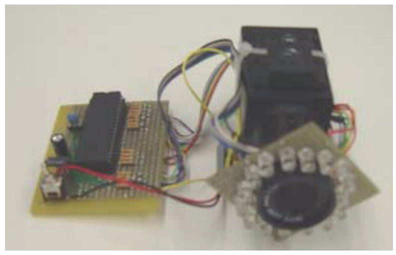


Fig.7 LED light that is installed the CCD camera

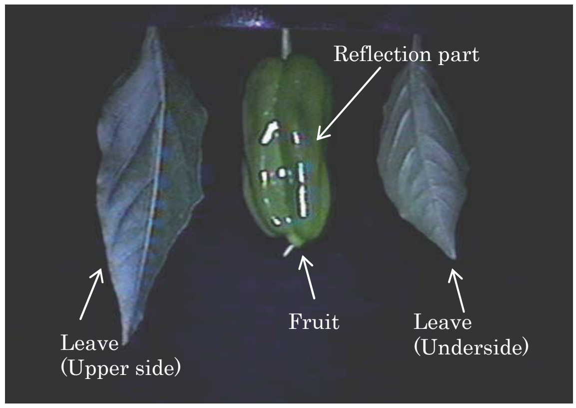


Fig.8 Captured image using white LED

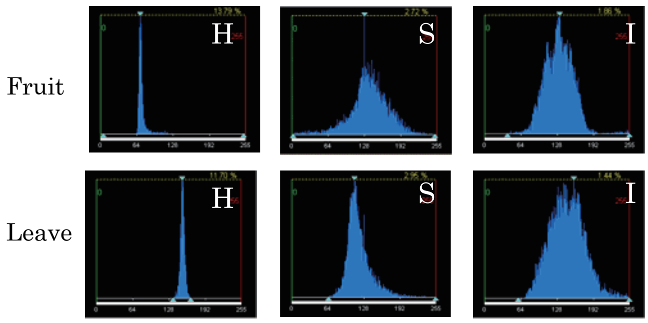


Fig.9 Gray value histogram (H; Hue, S; Saturation, I; Intensity)

3. Improved image processing algorithm

This reflection part appears to the surface of fruits, and this part doesn't appear to the surface of leaves. Therefore, if these parts are appeared, then there is a sweet pepper. This algorism is shown in Fig.10 and the example of image processing is shown in Fig.11. These reflection parts are high intensity and low saturation on HSI color specification system. The first step of image processing, these reflection parts are recognized by binarization of intensity and saturation. Next step, image-processing area is reduced to limited small area around the reflection part. The fruit of sweet pepper is recognized by binarization of intensity, saturation, and hue, in the limited small area.

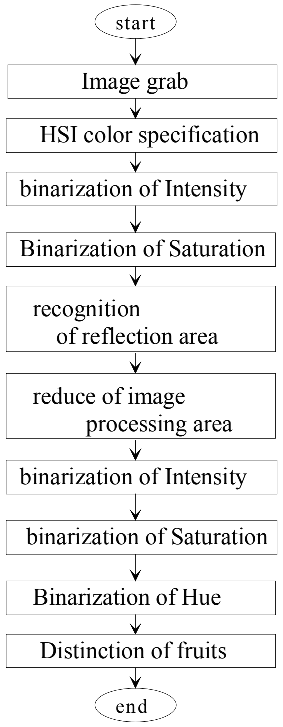
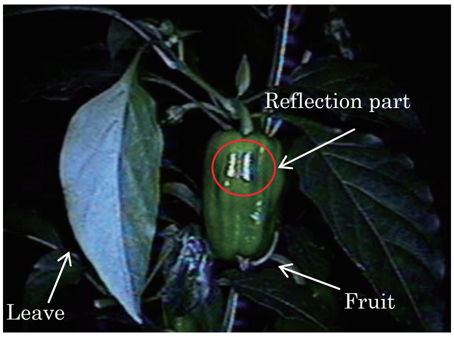
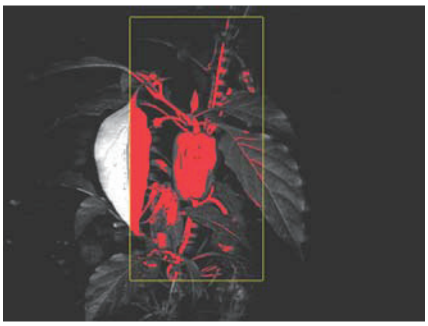


Fig.10 Image processing algorism

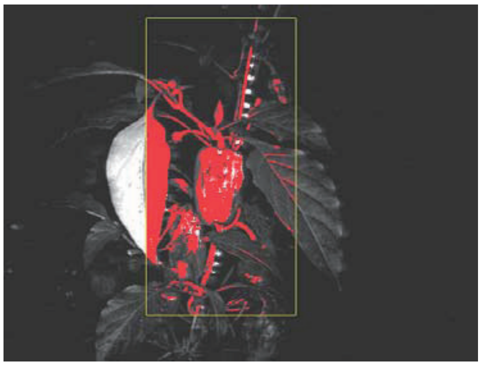


(a) Image grab

(b) Recognition of reflection part

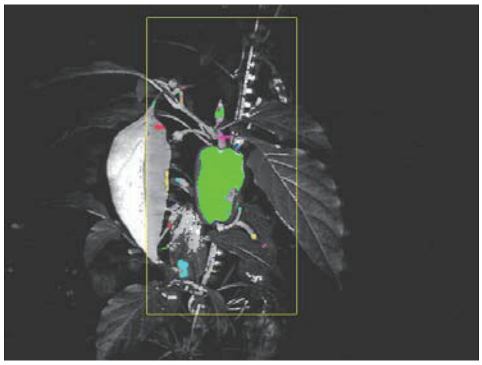


(c) Binarization of intensity in limited small area



(d) Binarization of saturation in limited small area

(e) Binarization of hue in limited small area



(f) Connect the area of contiguous part and fill in the part

(g) Distinction of fruit

Fig.11 Example of image processing

4. Experiment and result

Experiment were carried out in a greenhouse at night when is not affected by sunlight, as shown Fig.12. In this experiment, we get the images of 26 frames, and carried out image processing. In the result of experiment, fruits of sweet pepper are recognized by the distinction method using reflection of LED light on 21 frames, as shown in Fig.13-(a)-(k). However, on 5 frames, the refraction part did not recognized as shown in Fig.13-(l)(m). The distinction rate is 80.8 %, and there was not the erroneous result that was to recognize leaves.

5. Conclusion

In this report, we proposed a distinction method for fruits of sweet pepper using reflection of LED light, and experiments were carried out in greenhouse. In consequence, it was possible to improve the distinction ability. In the future, we examine this distinction method at many samples in greenhouses. And a method that the districted fruit of left camera correspond with it of right camera using reflection of LED light will be studied in the future research.

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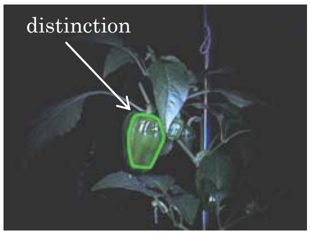
Fig.12 Experiment in greenhouse.

(a) Result-1

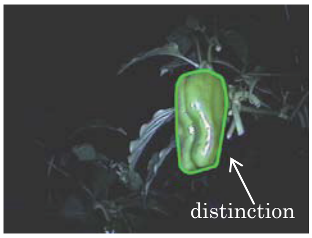
(b) Result-2

(c) Result-3



(d) Result-4

(e) Result-5



(f) Result-6

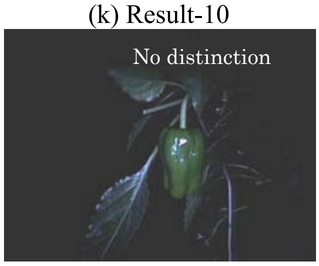
(g) Result-7

(h) Result-8

(i) Result-9

(k) Result-10

(l) Result-11



(m) Result-12

Fig.13 Example of results