Cherry recognition in natural environment based on the vision of picking robot

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Abstract. In order to realize the automatic recognition of cherry in the natural environment, this paper designed a robot vision system recognition method. The first step of this method is to pre-process the cherry image by median filtering. The second step is to identify the colour of the cherry through the 0.9R-G colour difference formula, and then use the Otsu algorithm for threshold segmentation. The third step is to remove noise by using the area threshold. The fourth step is to remove the holes in the cherry image by morphological closed and open operation. The fifth step is to obtain the centroid and contour of cherry by using the smallest external rectangular and the Hough transform. Through this recognition process, we can successfully identify 96% of the cherry without blocking and adhesion.

1. Introductions
As cherry retail prices soaring, cherry is planting positively in many places. However, with the increase of cherry planting area, cherry price competition will intensify. Because of cherry fruit small, cherry picking is difficult. Due to picking more time-consuming, this factor may lead to higher cost of cherry picking. Therefore, the use of cherry picking robot has become a trend. It can not only reduce the cost but also can solve the problem that the large area cherry needs to be picked in time in the mature season. Robot vision is the key function of cherry picking robot. It is the main factor to determine the success of cherry picking. There are many researches on pattern recognition [1-9]. In this paper, the recognition of cherry is a key problem in robot vision [10-11].

2. Image analysis
In the real environment, the cherry background is mainly the branches, leaves, cherry handle, the sky.

3. Cherry recognition methods

3.1. Image pre-processing
Cherry image will produce noise in the process of shooting, shooting techniques and equipment conditions. In this paper, 5 kinds of filtering are used to remove noise, which are block filtering, mean filtering, Gauss filtering, median filtering and bilateral filtering. Their experimental results are shown in Figure 1.
Figure 1. Pretreatment of cherry image

Figure 1 shows that median filtering is the best. Median filtering not only removes the cherry stalk but also removes the influence of illumination on the surface of a cherry. It removes the noise effectively.

3.2. Color feature extraction

The color of ripe cherries varies greatly with the branches, leaves, cherry stems, and the sky. Therefore, color feature extraction is very effective. There are a number of commonly used color models. In this paper, RGB model is used to identify the color image [12]. The cherry image is decomposed into 3 components: red, green and blue, as shown in figure 2.

Figure 2. The RGB component image of the cherry
Figure 2 shows that it is difficult to identify the color characteristics of cherry using only a single color component. The color of cherry image is produced by different proportion of red component, green component and blue component, so the relationship of the three components is studied. R-G, R-B, G-B, R/G, R/B, 2R-G-B, R-G/2-B/2, 0.9R-G, 0.9R-B were used to process the image of cherry, and the results were shown in figure 3.

![Figure 3](image)

**Figure 3.** Contrast diagram of nine kinds of color recognition methods

Figure 3 shows that G-B, R/G, and R/B methods are not accurate to identify the cherry shape. So these three kinds of color recognition methods are not successful. The 2R-G-B has produced obvious holes in the treatment of cherry images. Therefore, 2R-G-B is not a better method. R-B, R-G/2-B/2, 0.9R-B and R-G have basically the same effect to identify the image of the cherry, but the background processing results have a greater difference, that is, the background noise is more obvious. Finally, 0.9R-G is the best method to recognize of the cherry image or the processing of background noise, so the 0.9R-G as a method to identify the cherry. After the above color recognition, Otsu algorithm will be used to image segmentation of cherry [13]. If the image segmentation process is found to be a large amount of computation using the Otsu algorithm, we can use the evolution formula of the Otsu algorithm. \( P \) is the threshold for segmenting foreground and background, \( t_0 \) is the probability of the distribution of the foreground, \( h_0 \) is the average gray value of the foreground, \( t_1 \) is the probability of the distribution of the background, \( h_1 \) is the average gray value of the background. The average gray value of the whole image is \( h = t_0h_0 + t_1h_1 \). The variance formula \( \sigma^2 = t_0^2(h_0 - h)^2 + t_1^2(h_1 - h)^2 \) is established [14]. The experimental results are shown in the figure 4.
(a) Otsu algorithm  (b) The equivalent formula of Otsu algorithm

**Figure 4.** Otsu algorithm and Otsu algorithm of the equivalent formula to deal with cherry image

The experimental results show that the two algorithms have the same effect as shown in figure 4.

### 3.3. Area threshold removal noise

There are some holes and some noise in the image by the above process. So the area threshold is used to remove noise. We first find out the areas of different cherry in the image, and then find out the largest area of cherry. Finally, half of the largest cherry area is used as threshold to segment the image. Treatment results are shown in figure 5.

(a) Cherry image with noise inside  (b) Area threshold removal noise

**Figure 5.** Contrast figure of area threshold removal noise

Figure 5 shows that there are no holes in the image of the cherry. The noise is removed successfully.

### 3.4. Morphological operation

In general, there are holes and burrs in the image of cherry. These holes are filled by morphological close operation and open operation. The opening operation is first corrosion and then expansion treatment [15]. Image processing results are shown in figure 6.

(a) Cherry image with holes  (b) Closed operation  (c) Open operation

**Figure 6.** Morphological closed and open operation for cherry image processing

### 3.5. Using Hough Circle Transform to Extract Contour

Using canny operator for edge detection, cherry image processing effect is better. The experiment is shown in figure 7.
Figure 7. Cherry image processing using canny operator

The processed cherry image is drawn with a minimum external rectangle, as shown in figure 8.

Figure 8. Draws up minimum external rectangle for cherry outline

Hough is more used to circle and ellipse. Through the minimum external rectangle of cherry image, we get the radius of Hough transform. This reduces the amount of computation of Hough transform and avoids the retrieval of multiple centroid and contour in the same cherry. Experimental results are shown in figure 9.

Figure 9. Hough transform of the cherry image

4. Conclusions

It has great market application value for cherry picking robot. The most important part of the cherry picking robot is the recognition of cherry. This method is to use 0.9R-G for identify the colour, and then use the classical Otsu algorithm for threshold segmentation. If the Otsu algorithm is directly used to deal with a large amount of data, we can also use the equivalent formula of Otsu algorithm. When there are still noises and holes in the image, we can use the area to remove the noise and morphology to remove holes. Small holes can be directly used to open operation, without first for closed operation. Recognition of the key is to draw the centroid and contour of the cherry. We first use the canny operator to extract the outline of the cherry. However, the direct Hough transform will lead to recognition is not successful or long recognition time. So we can first find the minimum enclosing rectangle of contour of the cherry, and the Hough transform can successfully find the centroid and contour of all the cherries in the image.
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