A Review of Machine Vision Based Fruit Recognition Applications

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Abstract

Machine vision is widely used in various fields. The main applications in the field of fruit picking are fruit identification, fruit quality detection, fruit ripeness detection and grading, etc. And fruit ripeness detection technology is important to improve the quality and market competitiveness of fresh and stored fruits. This paper focuses on the application of machine vision in fruit identification, fruit ripeness detection and grading in the past three years, and the application is more mature in many fruits such as citrus, blueberry, cherry, etc. It uses a number of algorithms to enable accurate identification of fruits and processing of their images to control the robotic arm for a variety of operations such as picking.

Keywords: machine vision, image processing, edge detection, maturity inspection

1. Introduction

With the rising development of the modern economy, consumers have higher requirements for the quantity and quality of fruits. In order to reduce human losses during fruit picking and to save labor for more efficient picking, more and more machine vision technologies are being used in fruit picking and identification detection, etc.

Machine vision is the use of computers to simulate the visual function of the human eye, extracting information from images or image sequences, and identifying the form and motion of three-dimensional objects in the objective world [1]. Its ultimate goal is to use machines to fully interpret, simulate, reproduce and process human vision. In the future intelligent development of agriculture, machine vision technology will play a very important supporting role. And it will also face many technical challenges [2].

This paper is based on the application of machine vision in agriculture, especially in the field of fruit picking and identification in recent years [3, 4]. In the paper, we are writing about the key developments and research dynamics of machine vision technology in fruit recognition, and we do a detailed understanding and description of it. The main technology includes the use of image processing and other algorithms to complete operations. These operations consist of picking, defect identification and sort identification of citrus, navel oranges and other fruits.

2. Fruit (Citrus) Maturity Recognition

Citrus Research Institute of CAAS has proved that citrus peel color can be used as an indicator of citrus fruit maturity after experimental research. It provides the theoretical basis for the final realization of online automatic detection of citrus maturity.

Therefore, Zhuang Yibin and others from Zhejiang University of china have developed a machine vision system for non-destructive detection of citrus maturity. The machine vision system consists of CCD camera, image acquisition card, monitor, light box and computer [2].

According to the contrast of light source effects, the choice is to capture images of citrus against a white background. An image acquisition method was determined by building more than a dozen color models.

This image acquisition method is to obtain color pictures in RGB format through the camera for storage and display, and then convert them to HIS format for easy computer processing. The relationship between the RGB and HIS can be expressed as

$$\begin{cases} I = (R+G+B)/3 \\ S = I - \dfrac{[Min(R,G,B)]}{3} \\ W = cos^{-1}\left[\dfrac{2R-G-B}{2\sqrt{R^2+G^2+B^2-RG-GB-RB}}\right] \end{cases}$$

$$H = W, \text{ if } B \leqslant G \qquad H = 2^C - W, \text{ if } B > G \tag{1}$$

The study detected the green to orange color of citrus peel during the maturity process, and the color change was used to determine whether the citrus was mature or not.

3. **Fruit (navel orange) Identification Processing**

In the process of navel orange picking, the robot captures images in real time through the camera, and the field of view includes the sky, branches, leaves, fruits, and the earth, etc.

Moreover, there are overlapping, blocking, and uneven lighting, and the background is very complex, which puts the robustness of the recognition algorithm to a severe challenge.

To solve such problems, Guangli Chu et al. designed a machine vision-based method for sphere-like fruit recognition. The method first uses an image segmentation algorithm based on color normalization difference. It separates the fruit from the background [3]. Then uses a single-edge pixel tracking algorithm to extract the edges of the fruit, and uses a straight-line projection method to eliminate corner points. This step is done to improve the accuracy. Finally, the circles are detected by the least squares method to identify the fruit.

The algorithm can be divided into image Denoising processing, color segmentation, occlusion problem processing, and fruit recognition these four steps.

3.1. Image denoising processing

For easier post-processing, the image is first processed for noise reduction. The algorithm uses a Gaussian filtering algorithm to reduce the impact of image noise. Gaussian filtering is shown in the Fig.1.

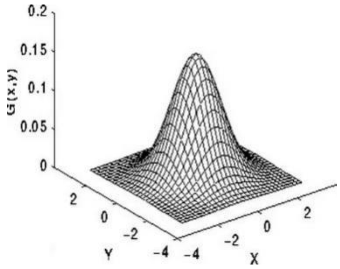


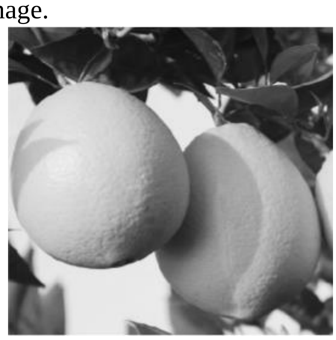
Fig.1. Gaussian filtering

3.2. Color segmentation

Considering that the mature navel orange is orange or red warm color, the fruit background is mostly green, cyan and other cool colors. The fruit and background colors are clearly distinguished, so the color segmentation can achieve good results. There uses normalized chromatic aberration for image segmentation. The relationship between the S and R、G、B can be expressed as

$$S = \frac{255(2R+B)}{2(R+G+B)} \tag{2}$$

When S⩾T (the fixed threshold), the pixel value of the point remains unchanged, and when S＜T, the point becomes black. Processing comparison images is shown in Fig.2, and image(a) is unprocessed image, image(b) is processed image.



(a) unprocessed image

(b) processed image

Fig.2. Processing comparison images

3.3. Occlusion problem processing

When the navel orange fruit is on the tree, there will be and other fruits or leaves block each other. The mutually blocked fruits or leaves must have cross corner points, here use the straight line projection method to eliminate the corner points, so that the edge of the two fruits at the cross point break. his allows for better identification of the navel orange.

3.4. Fruit recognition

Based on the fact that navel oranges are mostly round in shape, this study uses least squares to achieve circle detection. After initial processing to eliminate edges that are clearly not round, further processing determines round fruits. Circle detection result is shown in the Fig.3.

Fig.3. Circle detection result

Finally, the data is transmitted to the actuator for picking. The study used a machine vision algorithm to recognize 500 similar images and it achieved a processing time of 83.548ms and an accuracy of 95%.

4. Fruit (cherry) Defect Detection

Wang Zhao from Beijing Forestry University used machine vision technology to extract image information from the cherry surface. He proposed the corresponding image processing algorithm to achieve defect detection and recognition on the cherry surface.

Achieving cherry surface defect recognition is divided into two steps: cherry image background removal processing and cherry defect feature extraction.

4.1. Cherry image background removal processing

The first choice is to extract its R component to enhance the contrast between the cherry image and the background image. To facilitate the subsequent processing, it is converted into a Binary Image, Morphological processing is applied to enhance the image, after which the edge extraction algorithm is applied to extract the edges to get the cherry and defective contour edges.

Subsequently, the cherry contour is filled to get the complete cherry contour, the contour is filtered to remove the non-conforming contour.finally the original color image is filled.

4.2. Cherry defect feature extraction

According to the cherry defects mainly have four kinds of rotten, bird peck, scratches, deformed fruit. Among them, rotten in the image acquired by machine vision is manifested as a large number of spots in the binary map; bird peck and scratches are manifested as black irregular lines inside the edge of the image and other defect characteristics.

First of all, the obtained de-background map is weakened by the brightness of the reflective region, which is converted into a binary image. By eliminating the external contours, the defective binary image can be obtained.

5. Conclusion

This paper describes the application of machine vision for recognition and detection on fruits such as citrus, navel orange and cherry, including some operations of machine vision in this aspect, such as: image enhancement, image edge detection, etc. Understanding the specific operation steps and role of machine vision in fruit recognition in recent years.

With the refinement of neural networks, fuzzy control and other intelligent algorithms and the development of artificial intelligence, the richness and speed of image processing technology is greatly enhanced, coupled with the advent of the 5G era, will also lay the technical foundation for the further integration of machine vision technology and fruit picking and agricultural production.

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