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Research Article

A Survey of Machine Vision Applications for Fruit Recognition

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ABSTRACT

Machine vision has been widely used in the field of fruit picking in recent years, and its main application directions include fruit identification, fruit quality detection, fruit maturity detection and grading, etc. Among them, fruit maturity detection technology is of great significance for improving 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. They use some algorithms to accurately identify the fruit, process its image, and feed it back to control the robotic arm for picking and other operations...

1. Introduction

In recent years, with the steady development of society, agriculture has become more and more rapid and bigger. Consumers also need more and better fruits to meet their daily needs. 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]. The end result to be achieved by machine vision is the use of machines to fully interpret, simulate, replicate 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]. This paper mainly describes the application of machine vision in the field of fruit recognition, and makes a detailed understanding and description of the development trend and application research of its technology. What can be learned is that the main technologies in this area are image recognition, image signal conversion, image processing, system computing, etc. 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 (Chinese Academy of Agricultural Sciences) has proved that citrus peel color can be used as an indicator of citrus fruit maturity after experimental research. Based on this conclusion, one can complete the key identification part of the automatic detection of citrus maturity.

Therefore, Yibin Ying of Zhejiang University in China designed an image recognition system that can

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non-destructively detect the maturity of citrus by color. 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. Then, a variety of color models were established, and the image acquisition method was determined.

This image acquisition method obtains a color picture in RGB format through a camera, and this color picture is stored and displayed in a computer terminal. Then the RGB format pictures are converted to HIS format pictures for the computer to perform feature processing. The relationship between the RGB and HIS can be expressed as

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

$$H = W, \text{ if } B \leq G \qquad (1)$$
$$H = 2^C - W, \text{ if } B > G$$

This experiment showed that the color of citrus peel changed from green to orange 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, the captured real-time images contain 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 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 the following four steps, which are:

1. Image denoising process
2. Color segmentation
3. Occlusion problem processing
4. Fruit recognition

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 Fig. 1.

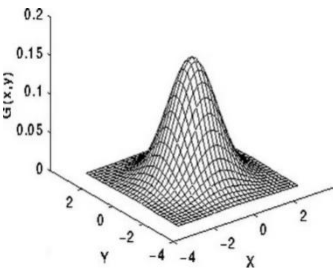

Fig. 1. Gaussian filtering

3.2. *Color segmentation*

Ripe navel oranges are warm colors such as orange or red, and the fruit background is mostly cool colors such as green and cyan.

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 and B can be expressed as

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

When S⩾T (the fixed threshold), the pixel value of the point remains unchanged, and when S＜T, the point becomes black. Next, compare the images before and after processing. The unprocessed image is shown in Fig. 2, and the processed image is shown in Fig. 3.

Fig. 2. Unprocessed image

Fig. 3. Processed image

3.3. *Occlusion problem processing*

Considering the position of navel orange fruits on the tree, they will overlap with other fruits or leaves, thus blocking 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. This 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 the circular detection process, the non-circular edge graphics are filtered out, and then the circular fruits are identified. Circle detection result is shown in Fig. 4.

Fig. 4. 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 [4].

To complete the defect identification task on the cherry surface, two steps are required: 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 make the image features more visible, it is converted into a binary image, and morphological processing is used to augment the image features. Afterwards, an edge extraction algorithm was applied to extract the edges to obtain 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*

There are four main types of common cherry defects, which are 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. And deformed fruits have various forms, such as twin fruits and stimulated growth fruits, which are characterized by irregularly shaped images instead of a circle or oval.

In order to achieve the cherry defect feature extraction, the image must be processed.

Firstly, the obtained de-background map is weakened by the brightness of the reflected area, and transformed into a binarized image. The cherry can be judged by the large number of spots in the map whether the cherry is rotten or not. Secondly, the image grayscale map is processed by custom multi-thresholding, and white defects and edges can be obtained. After color inversion, the defects and flips become black, and it can be observed whether there are black lines inside the cherry in the map and whether the cherry edge contour is regular round. Based on these, bird pecks, scratches and deformed fruits can be detected.

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 methods for image processing in machine vision applications, such as: image enhancement, image edge detection, etc. At the same time, it also further understands the specific methods of machine vision in fruit detection and recognition.

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. The development of 5G networks has also accelerated the development of machine vision technology, especially in agricultural production and fruit identification and picking.

References

1. Hongkun Tian, Tianhai Wang,Yadong Liu, et al., Computer vision technology in agricultural automation — A review. Information Processing in Agriculture, 2020, 7(1), pp. 1-19.
2. Ying Yibin, Rao Xiuqin, Ma Junfu. Methodology for nondestructive inspection of citrus maturity with machine vision (in Chinese). Transactions of the Chinese Society of Agricultural Engineering (Transactions of the CSAE), 2004, 20(2), pp. 144-147.
3. Chu Guangli, Zhang Wei, Wang Yanjie ,et al., A method of fruit picking robot target identification based on machine vision. Journal of Chinese Agricultural Mechanization, 2018, 39(2), pp. 83- 88.
4. Wang Zhao, Cheng Pengle, Huangpu Yilong, et al., Detection of Cherry Defects Based on NI Vision Assistant. Computer Science and Application, 2017, 07(12):1163-1173.

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