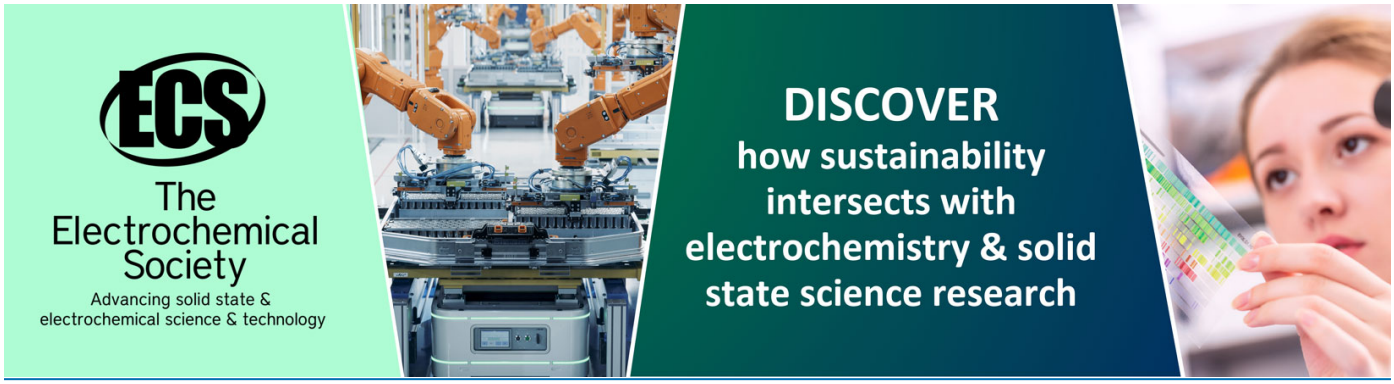
Detection of Fruit Surface Defects Based on Machine Vision



Detection of Fruit Surface Defects Based on Machine Vision

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Abstract. With the continuous improvement of social level, the perfection of fresh fruit surface has become a potential requirement for people to purchase. Aiming at the problems of high intensity and low efficiency in manual inspection, a method combining computer machine vision technology with MATLAB application was designed to detect the surface defects of fruits. Experiments show that this method has advantages in speed and precision in detecting fruit surface, and has certain application value.

Keywords: MATLAB, Machine vision, Fruit surface, Image processing, Defect detection.

1. Introduction

Fruits are rich in nutrients,With the improvement of social living standards, people's requirements for fruit quality and appearance are gradually increasing. According to the experience of most developed countries, most of the value of fruits depends on the degree of later processing, and fruit sorting has high timeliness and standardization. In the production process of factories, there are many criteria for fruit sorting, such as sorting by detecting external qualities such as weight, appearance size, skin damage and color, or sorting by internal qualities such as sugar content, effective acidity and internal defects. However, manual sorting requires more labor, and its accuracy is not as good as that of computer processing. Machine vision is a new and popular subject in this field, which aims to replace human eyes to do a series of image processing, and realize the functions needed by measurement and judgment. MATLAB, which has a powerful digital image processing toolbox, is used to realize machine vision, and a series of processing are done to the collected fruit pictures, including preprocessing and edge extraction, and finally the interesting places in the pictures, that is, the surface defects, are highlighted. This design can be nested with other equipment, which brings convenience to factory production and provides basis for subsequent exploration.

2. Machine vision and MATLAB

2.1. Machine vision

Machine vision is a hot branch of artificial intelligence, which is developing rapidly in recent years,It aims to use machines instead of human eyes for identification, measurement and judgment,It is mainly used in four typical fields, such as product defect detection, intelligent video surveillance and analysis, automatic driving and assisted driving, and medical image diagnosis. Its principle is to convert the image information collected by image acquisition equipment into digital signals, and then carry out a series of arithmetic processing. The main process is as follows: firstly, the captured target is converted into an

image signal, and then transmitted to a special image processing system to obtain various information of the captured target, which is converted into a digital signal; finally, the image system performs various operations on these signals to extract the morphological features of the target, thus achieving the desired results.

2.2. Overview of MATLAB

MATLAB is a commercial mathematical software produced by MathWorks Company of America, which is used in data analysis, wireless communication, deep learning, image processing and computer vision, signal processing and other fields. MATLAB is a software with simple language, convenient programming and high calculation precision, and has a powerful toolbox for digital image processing. Therefore, the design is developed by MATLAB, as long as the picture information of fruit is obtained, the defects of fruit surface can be marked with the image processing ability of MATLAB.

3. Main flow chart

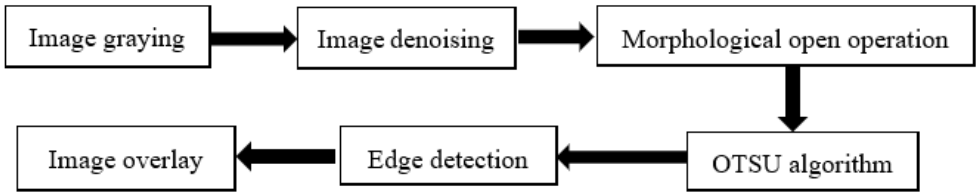

Figure. 1 Basic design scheme

3.1. Image graying

Most color images are RGB color models,When processing images, RGB components hould be processed separately,However, RGB cannot reflect the morphological characteristics of images, but only adjust colors from the optical principle. Grayscale processing is the processing of transforming color image into grayscale image,Image grayscale processing can be used as a preprocessing step of image processing, preparing for image denoising and edge extraction. Grayscale methods mainly include: maximum method, average method and weighted average method. In this design, the weighted average method is used to gray the color image,If the weights ωG, ωR and ωB satisfy the condition ωG>ωR>ωB, a reasonable gray result will be obtained. The research shows that when ωG=0.587, ωR=0.299 and ωB=0.114, the grayscale image is reasonable, that is, the main function in MATLAB is as follows:

$$Gray(i,j)=0.299*R(i,j)+0.578*G(i,j)+0.144*B(i,j);$$

3.2. Image denoising

Images collected by various image acquisition devices will be degraded for some reasons,Here, the noise generated during image digitization is mainly dealt with, and Gaussian noise is the main noise source. To evaluate the denoising effect of images, PSNR (Peak Signal to Noise Ratio), which is called Peak Signal-to-Noise Ratio in Chinese, is the common objective evaluation standard of images. Its main principle is to compare the processed image with each pixel of the original image, calculate the error value and determine the quality score of the distorted image. The scoring unit is dB, which is inversely proportional to the degree of distortion and directly proportional to the filtering quality and denoising effect. For Gaussian noise, the commonly used denoising method is domain mean filtering,Its principle is that in a square area (generally 3*3) in a picture, the pixel at the center point is the average value of all pixel values. Mean filtering is the above operation for the whole picture. It can be understood by the following 3*3 matrix template:

$$H=\frac{1}{9}\begin{bmatrix}1 & 1 & 1\\ 1 & 1 & 1\\ 1 & 1 & 1\end{bmatrix};$$

In addition to the 3*3 template, there are also 7*7 and 11*11 templates that can realize mean filtering on images, but the PSNR data obtained show that the 3*3 template has the best denoising effect, so the system uses the mean filtering of 3*3 template to preprocess fruit images. The functions in MATLAB are as follows:

```
I=rgb2gray (imread (''));
I=imnoise (I,'salt & pepper',0.1);
K1=filter2(fspecial('average',3), I)/255;
```

3.3. Morphological open operation

Starting operation refers to the operation of first corroding and then expanding the image, which makes the outline of the image smooth, breaks the narrow connection and eliminates the thin protrusions. Expansion is to expand the highlighted part of the image and expand the field, and the resulting rendering has a larger highlighted area than the original image; When operating, the adjacent area is replaced by the maximum value, and the highlighted area is increased; Corrosion causes the highlighted part of the image to be corroded away, the field is reduced, and the effect picture has a smaller highlighted area than the original picture; When operating, the adjacent areas are replaced by minimum values, and the highlighted areas are reduced. Starting operation is a filter based on geometric operation, which can remove the noise that is not clear in the image and filter some small objects.

Open operation can process images with different structural elements,Different sizes of structural elements will lead to different filtering effects,Different structural elements will lead to different segmentation, that is, different features

will be extracted. The main program in MATLAB is as follows:

```
f=imread('');
se=strel('disk',5');
g=imopen(f,se);
```

3.4. OTSU algorithm

OTSU (Otsu) is an algorithm to determine the threshold of binary image segmentation, which was proposed by Japanese scholar Otsu in 1979. From the principle of Otsu method, this method, also known as the maximum variance between classes method, is the best method to find the global threshold of images, and its application is self-evident, and it is suitable for most occasions that require the global threshold of images. It is not affected by brightness and contrast, but sensitive to noise, so it is necessary to filter the image noise first.

The main program in MATLAB is as follows:

```
I=imread('');
imshow(I);
bw=graythresh(I);
```

3.5. Edge detection

Sobel operator detects the edge according to the weighted difference between the gray levels of the upper, lower, left and right neighboring points of the pixel, and reaches the extreme value at the edge. It can smooth noise and provide more accurate edge direction information, but the edge positioning accuracy is not high enough. Sobel operator is one of the most commonly used and important operators in edge detection,The operator contains two groups of 3x3 matrices, which are horizontal and vertical,By plane convolution with the image, the brightness difference approximation of horizontal and vertical can

be obtained respectively. As shown below, Gx and Gy are approximate values of gray-scale deviation in the lateral and longitudinal directions, respectively.

$$Gx=\begin{bmatrix}-1 & 0 & 1\\ -2 & 0 & 2\\ -1 & 0 & 1\end{bmatrix};\ Gy=\begin{bmatrix}1 & 2 & 1\\ 0 & 0 & 0\\ -1 & -2 & -1\end{bmatrix}$$

The horizontal and vertical gray values of each pixel of the image are combined by the following formula to calculate the gray level of this point:

$$G=\sqrt{Gx^2+Gy^2};$$

Generally, in order to improve efficiency, an approximate value without square is used:

$$|G|=|Gx|+|Gy|;$$

If the gradient g is larger than a certain threshold, the point (x,y) is considered as an edge point. Then the gradient direction can be calculated by the following formula:

$$\Theta=\tan^{-1}\frac{Gy}{Gx};$$

When the precision is not very high, Sobel is a commonly used edge detection method,This design requires that the defect boundary of fruit pictures can be roughly detected, and the precision is low, so Sobel operator is adopted.

3.6. Image overlay

Image superposition refers to the pixel addition of multiple images, that is, the summation of corresponding points,It is required that the dimensions of the two images must be the same, and the rows and columns must be equal, otherwise it cannot continue. Here, the image edge detected in the previous step is superimposed on the picture of the initial image, and the shape and position of fruit surface defects are accurately located,Finally, the detected fruit surface defects are marked with a matrix box. The main program in MATLAB is as follows:

```
m = misread ('');
m1 = misread ('');
result = Imad (m, m1);
```

3.7. ROI region selection

For an image, the area we need to process only accounts for a small part of the whole image,We can display the image manually by using the mouse, and we can get the initial row and column coordinates of the ROI image.

4. Experimental results

In order to test whether the fruit surface defects can be detected by the above method, the related experiments were done in MATLAB according to the above method (taking the pictures of rotten apples as an example), and the experimental results are as follows:

Figure 2. Example

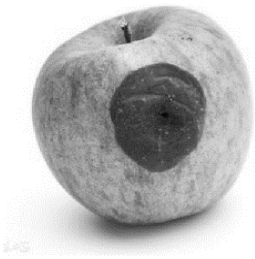

Figure 3. Image graying

Fig 2. is a fruit picture collected by photo collecting equipment without processing, and Fig 3. is the result of gray processing on the image.

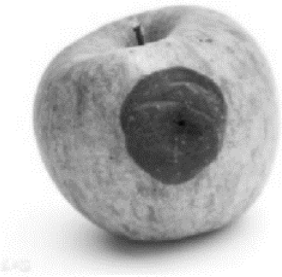

Figure 4. Image denoising

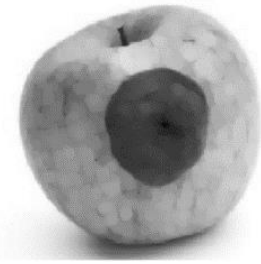

Figure 5. Morphological open operation

Fig 4. is the result of image denoising, and Fig 5. is the result of morphological operation on Fig 4., The series of processing results show that the image preprocessing is successful.

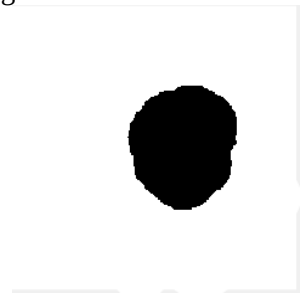

Figure 6. OTSU algorithm

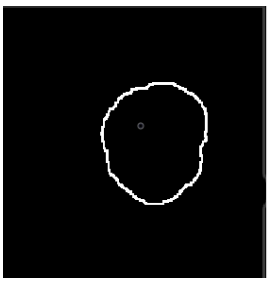

Figure 7. Edge detection

Figure 8. Image overlay

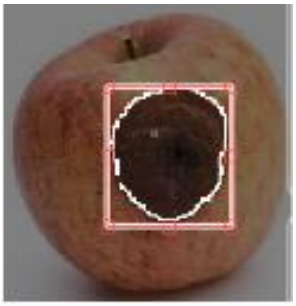

Figure 9. Achievements

Fig 6. is the result of binarization of Fig 5. by OTSU algorithm, and then edge extraction of binarized image by Sobel operator is carried out to obtain Fig 7. The extracted edge is superimposed with the

original image by using the image superimposition algorithm to obtain the Fig 8., and the Fig 9. is obtained after marking.

From the final results, this method can successfully detect and extract the edge of rotting area.

5. Conclusions

Through the above experiments, it is proved that the fruit surface defects are successfully detected by combining the related theories of machine vision technology with the application of MATLAB, which shows that this method has certain feasibility and can provide effective theoretical support for subsequent related research. However, there are some defects in this design, and the effect of detecting some minor defects and defects similar to fruit color is not ideal.

References

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