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Citrus Appearance Quality Grading System Based on OpenCV Image Processing

Yiqin BAO[a1] , Qin LIU[a] and Yulu BAO[b]
[a] *College of Information Engineering of Nanjing XiaoZhuang University, China*
[b] *Nanjing RuiHuaTeng Intellectual Property Co., Ltd., China*

Abstract. The production technology of Citrus in China is still at the initial stage of development, and the classification of Citrus mainly depends on manual work, which is subjective and inefficient. To solve the problem of time-consuming, laborious and low efficiency of citrus classification, this paper uses the OpenCV image processing technology, Candy edge detection operator for edge detection and DP algorithm for contour extraction to find the two points with the largest distance in the contour to achieve citrus diameter detection; The RGB color space is converted into HSV color space, and the parameters of H component are extracted to obtain the citrus coloring rate, thus realizing the citrus appearance quality grading system. The experiment proves that the accuracy of diameter detection is more than 99%, reducing the artificial classification deviation.

Keywords. OpenCV, Image recognition, feature extraction, edge detection

1. Introduction

China is the largest fruit farmer in the world, and the planting area and output of its fruit rank first in the world. At present, China's fruit industry has become the main agricultural product next to grain and vegetables. China is the largest Citrus producing area in the world, with rich Citrus resources and excellent varieties. The planting history has exceeded 4000 years. China's Citrus output reached 23.31 million tons in 2008, surpassing Brazil and ranking first in the world [1]. Although China's Citrus output is large, the fresh Citrus exported each year only accounts for a small part of the global Citrus trading volume, and the prices of most varieties are very cheap. However, developed countries such as Europe and the United States have always monopolized the high-end market. This is mainly due to the backward post harvest inspection and grading technology in China and the low degree of post harvest commercialization, resulting in uneven varieties and varieties.

At present, the grading treatment of citrus before sales in China is mainly manual, which is time-consuming, labor-intensive and inefficient. The use of computer vision technology to classify fruits has become a development trend. There have been relevant studies, He et al. [2] has made a review of fruit quality detection based on machine vision, Xiong et al. [3] have made a study on the quality detection technology of litchi fruit during picking, Shi et al. [4] have studied the online grading detection of apple

[1] Corresponding author: Yiqin BAO, email: 392335241@qq.com

quality, and Rao et al. [5] have made a study on the external quality grading method of spherical fruits based on machine vision. However, there is no relevant data on citrus quality grading, and a complete detection system has also been formed.

In this paper, based on openCV image processing technology, Candy edge detection operator is used for edge detection and DP algorithm is used for contour extraction to find the two points with the maximum distance in the contour to achieve citrus diameter detection. The fruit area in each component channel image of RGB (red, green, blue), HSV (Hue, Saturation, Value) and other color spaces in the color space is extracted to extract the size, shape, color and other characteristics of the fruit, The citrus appearance quality classification system is realized.

The contributions and innovations of this paper are summarized as follows:

1) Design the structure of citrus grading system.
2) The related technology and citrus grading were studied.
3) The detection system is realized through QT.

The rest of the paper is organized as follows. The second section studies the relevant technologies, the third section designs the structure of the citrus grading system, the fourth section realizes the citrus quality grading, the fifth section conducts experiments and compares with manual work, and the sixth section summarizes the full text and prospects.

2. Related technology

2.1 OpenCV

OpenCV is a cross platform, lightweight and open source computer vision library, which supports various machine languages [6]. Opencv module covers all fields. Including character recognition, image processing and license plate recognition. OpenCV contains more than 300 C language function APIs in the middle and high levels. It has strong visualization ability and is suitable for the experimental environment of this paper. The advantages of OpenCV over other computer vision tools are shown in Table 1.

Table 1. Comparison of image processing and computer vision tools

Development tool	Developer	Application area	Is Free	Is the source code open
IPL	Intel	Image processing	Free	Not open
OpenCV	Intel	Image processing, computer vision	Free	Open
IPP	Intel	Image processing, signal processing	Not free	Not open
VisDSK	Microsoft	Image processing	Free	Open
Mattlab	Microsoft	Multidisciplinary	Not free	Not open

2.2 Freeman chain code

Chain code is a common graphic expression method, which can well express graphics [7]. Direction chain code is an effective coding method to describe the boundaries of graphics. It defines a direction and encodes the edges of an image on this basis, so as to form a set of connected sequences with a certain length and direction. At present, free chain codes and bribiska codes are more common.

In this paper, free chain codes are used to output curves. Free chain codes generally use eight directions, namely 0, 1, 2, 3, 4, 5, 6, 7 and 8. Starting from the starting point, the pixel values in the eight directions are detected counterclockwise and clockwise, as shown in Figure 1.

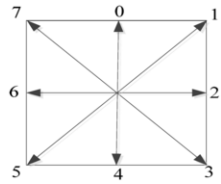

Figure 1. Eight directions of Freeman chain codes

Image detection is performed from top to bottom and from left to right. After the boundary point is detected, it is taken as the starting point of the detected edge and stored in the chain code. Then, it will go down until it returns to the starting position of the edge to complete its detection. And stores distribution information in eight directions in the chain code. Its expression is shown in Table 2.

Table 2. A contour free chain code table structure

(x_0, y_0)	n	B_0	B_1	B_2	...	...	B_{n-1}

In Table 2, $(x_0, y_0)$is the coordinate of the starting point of tracking along the boundary, n is the total number of points along the boundary, and B is the order of chain codes.

2.3 DP algorithm

Generally, Freeman chain code operation can be performed directly after contour extraction. Its feature is the contour feature, and its description is the description of the contour. Because the steps of chain code are very short, it is very difficult to describe the edges directly. In this paper, the DP algorithm is used to approximate the polygon, so as to obtain the initial shape of the polygon, find the optimal number of polygon sides, and then approximate other sides with the same number of sides to obtain the polygon with the same number of sides. So that the same feature points can be obtained as much as possible after polygon approximation.

2.4 Canny boundary detection algorithm

Canny boundary detection operator uses 2 × 2 The amplitude and direction of the image gradient obtained by the first order partial differential of the adjacent region through Gaussian filtering. The first order partial derivatives of X and Y directions can be expressed as formulas (1) and (2).

$$p_x(x,y) = \frac{[H(x,y+1)-H(x,y)+H(x+1,y+1)-H(x+1,y)]}{2} \tag{1}$$

$$p_y(x,y) = \frac{[H(x,y)-H(x+1,y)+H(x,y+1)-H(x+1,y+1)]}{2} \tag{2}$$

The amplitude and direction of the image gradient can be expressed in ways (3) and (4).

$$M(x,y) = \sqrt{p_x^2(x,y) + p_y^2(x,y)} \tag{3}$$

$$\theta(x,y) = \arctan\left(\frac{p_x(x,y)}{p_y(x,y)}\right) \tag{4}$$

In the system implementation, we use Canny operator to detect the boundary. Canny operator can achieve a good balance between false detection and missed detection, and has a good edge detection performance.

3. The System Overall Structure

3.1 System archetecture

The system adopts the classic three-layer design mode of the Internet of things, namely, the perception layer, the network layer and the application layer; The system adopts B / S architecture and takes the database as the center to build the system. The system block diagram is shown in Figure 2.

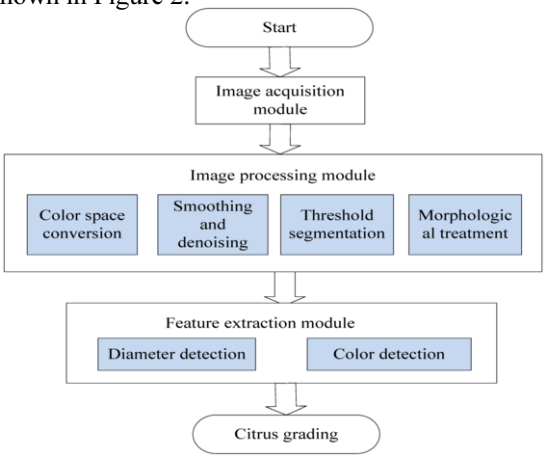

Figure 2. System archetecture diagram

3.2 Citrus Quality grading

3.2.1 Grading method

The grade indexes of fruit appearance quality include size, shape, color, surface defects, etc. According to the fruit grading standards issued by the state, fruit dealers divide them into different grades for packaging, so as to increase the added value of products. There are three main fruit classification methods: manual classification, mechanical classification and machine vision.

3.2.2 Grading standard

This paper studies the classification standard of citrus, mainly from the two aspects of fruit diameter and color, and gives the evaluation standard. The classification standard is shown in Table 3.

Table 3. Citrus grading standard

Grade	Fruit diameter	Coloration rate
Super grade	>=85	>80%
First grade	75-85	70%-80%
Second grade	65-75	60%-70%
Third grade	<65	<60%

3.3 Diameter detection

The Citrus diameter detection module can recognize and extract the outer contour of the Citrus fruit surface, and detect the diameter according to the two points with the largest distance in the contour. The diameter detection module is mainly composed of the original Citrus image, color space conversion, median filter denoising, threshold segmentation to obtain a three-dimensional image, morphological processing to remove noise, obtain an image, background segmentation, image extraction, adaptive threshold segmentation, edge removal processing, remove small areas, obtain contours, draw diameter contours, and calculate Citrus diameters. The flow chart is shown in Figure 3.

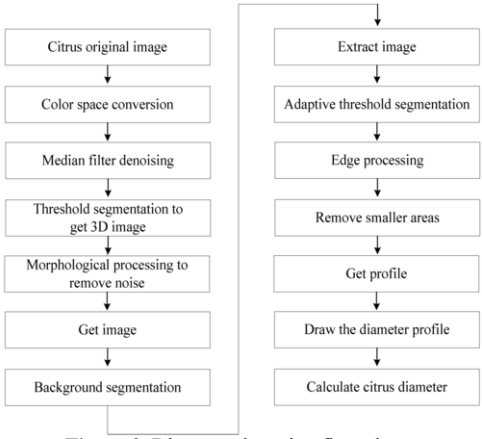

Figure 3. Diameter detection flow chart

3.4 Coloration rate detection

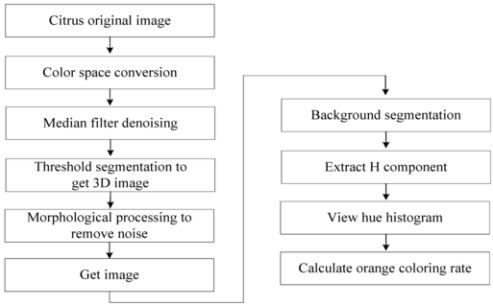

Figure 4. Color detection flow chart

Color is a major factor affecting the appearance quality of oranges. Oranges with uniform color and uniform color have high merchantability. In the process of post production commercialization of oranges, varieties with similar color and luster are often classified [8]. Therefore, in the classification of citrus, color is a big problem. The color detection module is mainly used to classify the color consistency of citrus. The

module describes the color of Citrus according to the distribution of hue characteristics of Citrus images, and divides Citrus into three color grades. The flow chart is shown in Figure 4.

4. System test and comparison

In order to achieve citrus and color grading, we have implemented the system and tested it. This paper uses Pycharm platform as the program deployment platform, and uses QT component programming interface. The operation effect is shown in Figure 5. It can be seen that the measured diameter of the orange is 36.2mm, which is verified to be correct through actual measurement with a ruler. The color shade is 57.6%, so the orange is tested to be Third grade.

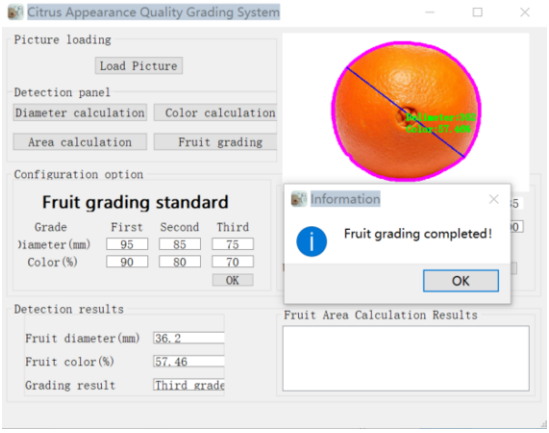

Figure 5. Citrus grading test interface

Through the comparison between manual and systematic tests, as shown in Table 4, the accuracy of citrus measurement can reach 99%, which can reach the level of practical application.

Table 4. Comparison of citrus diameter test results

Fruit No	Manual test results/mm	Repeat measurement results/mm					Maximum positive deviation/mm	Maximum negative deviation/mm	Accuracy
		1	2	3	4	5			
1	80.5	80.6	80.8	81.0	80.2	80.0	0.5	-0.5	99.4%
2	70.3	70.6	70.5	70.3	70	70.7	0.4	-0.3	99.3%
3	66.5	66.4	66.5	66.7	66.4	66.3	0.2	-0.2	99.6%
4	36.2	36.1	36.2	6.3	6.2	36.1	0.1	-0.1	99.7%

5. Conclusions

In view of the characteristics of artificial classification, low efficiency and poor accuracy of Citrus color detection in China, this paper uses image processing technology to classify the color of citrus, designs a Citrus appearance quality classification system based on image processing, studies the image pretreatment and feature extraction methods of citrus, and realizes the diameter and color classification of citrus.

This paper only realizes the citrus defect and color grading, which can combine the citrus shape, defect and other features with the color features. However, the next content to be studied is to achieve all-round citrus quality detection through depth learning methods.

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