Segmentation and Localization Method of Greenhouse Cucumber Based on Image Fusion Technology

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***Abstract* — In order to facilitate the extraction of the feature points and obtain the three-dimensional coordinates of the greenhouse cucumber, a segmentation and localization method based on image fusion technology is proposed, and the RGB image and depth image of the plant are extracted by using Kinect sensor.Firstly, the RGB image is segmented based on the color and region growing. Then, the target contour is extracted from the image, and then the feature values of the tangent point and the centroid are extracted from the following mathematical and morphological processing.Then the 3D information and image feature points coordinates are fused by using the calibrated KINECT depth camera.Determining the three-dimensional coordinates of the feature point of the fruit.Through experiments, the error rate is about 1.9mm, which can meet the requirements of picking robot.**

Keywords - Image segmentation; Kinect; Three-dimensional coordinates

I. INTRODUCTION

With the rapid development of computer technology, computer vision technology is increasingly applied in various fields, robot vision system as a part of computer vision has been made great progress.Because of the complexity of crop growth, it is difficult to segment the fruit.So how to quickly and accurately locate the point coordinates of the fruit is an important criterion to measure the performance of a picking robot, but also picking robot research Popular.

In recent years, domestic and foreign scientists have done a lot of research on the vision system.Japanese scientist Kawamura etal have put tomatoes into research.Using G-B chromatic aberration between fruit and background, the fruit is identified, and the 3D coordinates of binocular distance measurement is obtained by using the triangle principle.The cucumber was studied by IMAG in Holland, which used near infrared vision system for identification of cucumber fruit and achieved good results.Wang Haiqing of Nanjing University based on adaptive pulse coupled neural network method for the segmentation of Cucumber.Song Jian of the China Agricultural University in the G-B chromatic aberration on the eggplant for double fixed threshold method, and the use of single eye system two step method to extract the three-dimensional coordinates of the feature points.But the past research is the use of infrared camera or stereo CCD camera, the price is expensive, it is difficult to promote agricultural picking robot.

In this paper, the Kincet stereo sensor is used as a tool to study the greenhouse cucumber.RGB camera and infrared laser camera were used to capture the color and depth image, after a series of processes to achieve the segmentation of cucumber and the effective measurement of the 3D coordinates of the feature points.

II. MATERIALS AND METHODS

A. Image system acquisition

Kinect is equipped with a XBOX360 game machine, the visual acquisition system consists of 1 RGB color camera and a pair of depth camera.The acquisition of the pixel is 640 ×480.

Image location for Shouguang City high-tech agricultural industrial park in the greenhouse, acquisition time of 5 p.m.Image acquisition program development method is VS2010+Opencv+SDK.The collected RGB and depth images are shown in Fig.(1):

Fig.1 The image acquaint by Kinect

B. Choice of color space

The choice of color space is the first consideration in the robot vision system. The different color spaces have different characteristics. The color space of LAB, RGB, HSV, HSL and so on. In order to compare the difference between the fruit and the background in the color space, this paper will convert the RGB color image into HSL, Lab, HSV, etc.

Fig.2 Each color space

After comparison, the difference between the fruit and the background of the HSL was obvious., so this paper chooses HSL as the processing space.HSL is a kind of color space model, in which the H L S is hue saturation and brightness.The relationship between RGB and HSL:

$$H = \begin{cases} \theta & (G \geq B) \\ 2\pi & (G < B) \end{cases} \quad (1)$$

$$\theta = ar\cos\left[\frac{0.5(R-G)+R-B}{\sqrt{(R-G)^2+(R-B)(G-B)}}\right] \quad (2)$$

$$S = 1 - \frac{3}{R+G+B}\min(R,G,B) \quad (3)$$

$$L = \frac{1}{3}(R+G+B) \quad (4)$$

III. IMAGE SEAMENTATION AND FEATURE EXTRACTION

A. *Image preprocessing*

As the image acquisition in the greenhouse, so some of the problems such as uneven illumination caused some noise, this paper using bilateral filtering algorithm for image noise reduction filtering.Bilateral filtering is a nonlinear filtering method,which is a compromise between the spatial proximity and the pixel value of the image, taking into account the spatial information and intensity similarity, to achieve the purpose of edge-preserving denoising.A simple, non-iterative, local characteristics.

B. *Image segmentation based on region growing*

Firstly, the image is put into the color histogram, and the color points and the color histogram of the fruit are extracted by using PS software.Select the 6*6 pixel area, set the threshold, and count the number of pixels within the region less than the threshold.If greater than 20 may be considered to be the fruit class of objects, it is filtered to less than 20.The growth point is selected by using the above method to divide the fruit and the background color, However, due to the presence of fruit color similar to the pixel blocks, it needs to be further processed.Filtering and growth factor segmentation results are shown in Fig.(3).

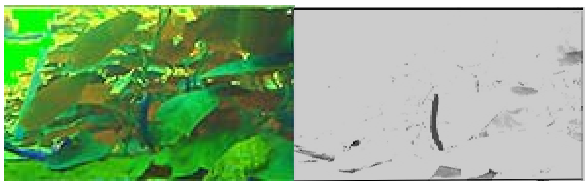

Fig.3 The image of filtering and split of Growth area

C. *Target extraction based on contour features*

After the segmentation, the image is processed by two straight processing, extracting each contour. Then the target is extracted and the steps are as follows:

1）Calculate the area of all the contours, set the size of the valve, and filter all the contour which is less than the second valve

2) According to the characteristics of cucumber fruits.Seeking the angle between the line connectioned by the top and bottom pixel values of the contour and the vertical of the image.Noise removed if the angle is greater than 30 degrees

3) Calculate the difference between the X and the Y coordinates of the top and the bottom pixels,if the difference is greater than 1/3, it is filtered.

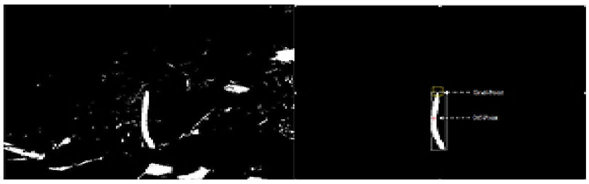

Fig.4 feature extraction

After the above steps, the target contour information is extracted.Extracted centroid, cut points, and minimum bounding rectangle according to the outline.The effect diagram is shown in Fig.(4).

IV. THREE-DIMENSIONAL INFORMATION EXTRACTION

A. *kinect ranging principle*

Two infrared cameras transmit the infrared, according to the triangle principle to get the real world of depth image.Equivalent to mm.

The laser emitter of Kinect emits infrared speckle, which is received and compared with the reference image stored in the camera by another infrared camera.Reference image is taken as the reference plane image of a certain distance.

If there is a difference between the target and the reference plane, the laser speckle on the infrared image can be offset by d, which is based on d to calculate the depth image.Let b two cameras directly baseline, f is the focal length of the camera, d is the offset. z_k is the reference range, the target point and the target distance are D, as shown in Fig.(5).

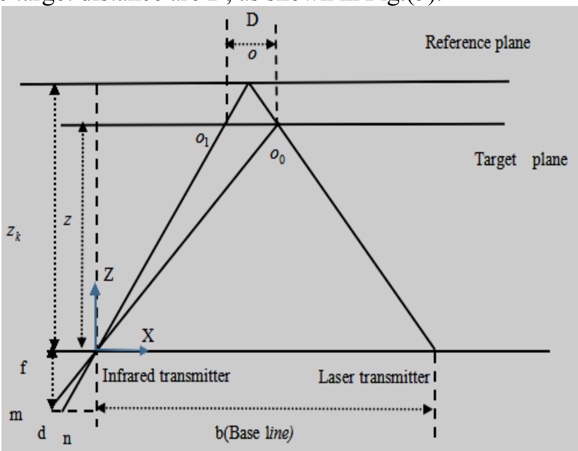

Fig.5 Relation between relative depth and measured disparity

According to Fig.(5):

$$\frac{D}{b} = \frac{z_k - z}{z_k} \quad (5)$$

$$\frac{d}{f} = \frac{D}{z_k} \quad (6)$$

$$z = \frac{z_k}{1 + \frac{z_k}{bf} d} \quad (7)$$

B. Calculation of coordinate position of fruit

Because of the distortion of the stereo camera, the error of the measurement of 3D coordinates is made.So the infrared camera is calibrated by Heikkia calibration method,removing distortions, in order to improve the measurement accuracy.So it is necessary to calibrate the coordinates of the two to be able to perform image fusion.Calibration is performed using MapDepthToColorImagePoint() function provided by Kinect SDK.Let dx and dy be the pixels in the image coordinates x,y axis direction on the unit size.The two coordinate system can be expressed as:

$$u = x/dx + u_0 \,, v = y/dy + v_0 \quad (8)$$

So the relationship between the RGB image and the world coordinate system is shown in Fig.(6):

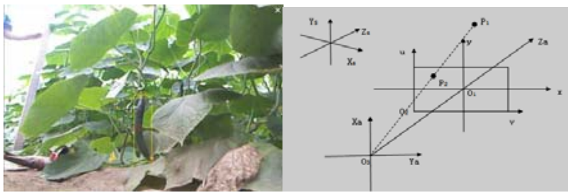

Fig.6 The Change of three kinds of coordinates

V. EXPERIMENTS AND ANALYSIS

In order to verify the correct performance of the method, 10 sets of experiments were done in the laboratory and in the greenhouse.

A. Segmentation experiment

First, in the greenhouse, the collection of 4 cucumber photos, the acquisition tool for Kincet pixels 640*480.PC for E430 Thinkpad, clocked at 2.4GHZ ,memory for 4G.Processing color space is HLS, the acquisition time is the next night.The processed image is shown in Fig.(7).

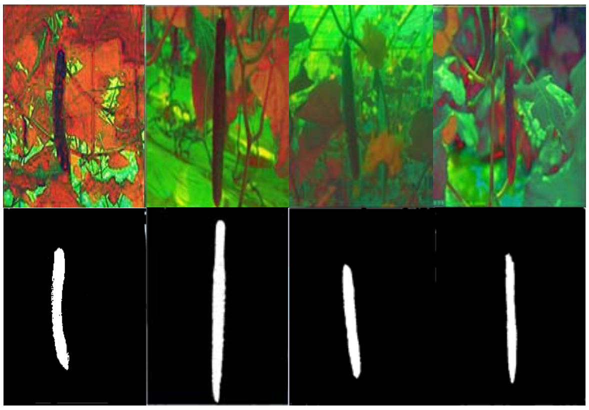

Fig.7 Experiment of division

From the image processing results showed that segmentation success rate without obstacles is almost 100% , but the work time only in the evening or night. this is due to the limitations caused by Kincet itself.

B. Ranging experiment

In order to verify the accuracy of measuring the three-dimensional coordinate and facilitate the measurement,the distance measurement experiment is conducted In the laboratory standard measurement table.because of the limitation of Kincet itself, the measurement distance is 1000mm~3000mm,and the 11 sets of data are collected.as shown in Table 1:

Ranging experiments were performed using calibrated sensors.the maximum error is 12mm, which can meet the requirements of the robot's acquisition precision.However, due to the limited range of Kincet, ranging can only be more than 1000mm.

TABLE 1. THREE-DIMENSIONAL COORDINATES MEASUREMENT RESULT(MM)

Test No.	Actual Coordinates	Actual Coordinates	Measuring Coordinate
1	(1000,200,60)	(1000,200,60)	(1003,204,58)
2	(1100,-200,100)	(1100,-200,100)	(1097,-195,103)
3	(1300,150,150)	(1300,150,150)	(1296,149,153)
4	(1600,-50,-80)	(1600,-50,-80)	(1598,-49,-77)
5	(1800,60,120)	(1800,60,120)	(1786,65,124)
6	(2000,120,70)	(2000,120,70)	(1974,116,72)
7	(2250,100,80)	(2250,100,80)	(2246,98,77)
8	(2300,200,90)	(2300,200,90)	(2298,192,93)
9	(2400,-100,80)	(2400,-100,80)	(2339,-91,83)
10	(2600,-50,50)	(2600,-50,50)	(2564,-40,41)
11	(200,100,100)	(200,100,100)	(0，0，0)

VI. CONCLUSIONS

In this paper, Kinect is used as a tool to segment the cucumber and the 3D measurement of the feature points.Select HLS as the color space, use region growing algorithm based on color to segment and extract the target fruit according to the contour features.3D coordinates calculation based on image fusion.After the experiment, the efficiency and the accuracy of the segmentation can meet the requirements of the picking robot.A simple and practical method is provided for the vision system of the picking robot.But this paper is in the initial stage of cucumber vision system, and the extraction of fruit under complex conditions remains to be further studied.

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