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Cluster Prickly Ash Image Recognition and Picking Point Location Based on Multistage Image Transformation and Growth Characteristics

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ABSTRACT

In view of the complicated picking geographical environment of Chinese Prickly ash, the picking time is limited, which makes it difficult for manual picking to deal with various problems in the picking process. This paper puts forward a based on multistage image transformation and growth characteristics of clusters of Chinese prickly ash image recognition and picking point positioning method, first by multistage image transformation fruit contours of Chinese prickly ash, calibration, and then to the regional picking point location, according to the last complete picking point positioning using the growth characteristic of Chinese prickly ash. The results show that this method has high recognition accuracy and accurate positioning, which can meet the demand of the picking point location of Chinese Prickly ash, and provide important technical support for the design of the cutting Chinese prickly ash picking robot.

Keywords: *Chinese prickly ash; Color model; Image recognition; Algorithm; Picking location*

INTRODUCTION

Prickly ash is widely cultivated as a cash crop in China. It not only has high edible and medicinal value, but also has strong adaptive root system and good sand control and soil fixation function. Therefore, it is one of the ecological economic tree species with good economic benefits[1-4]. But there are the following difficulties in picking prickly ash: (1)Chinese prickly ash is mostly planted on the hillside, hill, land and shore, and the picking geographical environment is complex; (2)The fruit is small and light, the ears are clustered on the shorter stalks, the dry branches are prickly, the petioles and lobules are also prickly, and it is easy to cause physical injury during picking[5]; (3) The branches are long and soft, and improper use of force will easily cause the branches to break. Improper picking positions or techniques will damage the buds and affect the yield of the next year; (4) If the fruit is not picked in time, it is easy to automatically crack. If it is cloudy and rainy, it will become black and dark, and affect the product quality. Therefore, it needs to be picked timely and efficiently in sunny weather [6].In short, the geographical environment in which Prickly ash is picked is complex. In the process of picking, it is not only required not to hurt the leaves, buds and branches to ensure the yield of the next year, but also requires efficient and timely harvesting to ensure the quality of products, which leads to prominent problems such as low efficiency of Prickly ash harvesting and difficulty in improving the yield. It also puts forward urgent demand for mechanized picking by fruit and vegetable picking robots.

Because in the picking process of the fruit and vegetable picking robot, it is necessary to recognize and locate the ripe fruit through the vision system first, and then transmit its coordinate information to the robot driving device to drive the movement of the robot arm, so that the end-effector carried at the end of the robot arm is close to the target position, store the fruit picking, therefore, efficient fruit image recognition and accurate location of picking area is the primary task that the vision system of fruit and vegetable picking robot must accomplish[7]. Lufeng Luo et al. used the improved artificial bee colony optimization fuzzy clustering method to segment and recognize grape fruit images[8]; Sashuang Sun et al. designed a kind of fetching model based on visual attention mechanism, extraction of outstanding fruit area, strong resistance to noise, the goal of overlapping fruit, Ncut algorithms on extraction of apple for precise segmentation, and then the three circle fitting method was adopted to split each apple goal after refactoring, the improved Grab Cut model had an apple region extraction accuracy of 94.08%[9]; Juntao Xiong et al. used the HSV color model for threshold segmentation to remove the complex background of litchi image, and used the fuzzy C-means clustering method (FCM) to segment the litchi fruit and fruit stem in the image, and the accuracy of identifying the fruit and fruit stem reached 93.3%[10]; Dejiang Liu et al. by using frequency domain enhancement of image processing, image in the frequency domain, using homomorphic filtering to enhance the soft dates kiwi fruit image, prominent characteristics of the trunk, reduced the influence of the background noise, and at the same time binocular stereo vision system was used to identify the position of fruit, in order to improve the recognition accuracy and the effectiveness of the proposed method is verified by experiment[11]; Xiangqin Wei et al. extracted color features in OHTA color space as the input of Otsu threshold algorithm, and automatically calculated segmentation threshold. This method realized the automatic extraction of fruit targets, and the output results were displayed in the form of binary images, with an extraction accuracy of more than 95%[12].

It is not difficult to find from the above research on fruit and vegetable picking technology that compared with the above fruits and vegetables with large difference in color and single fruit without shade, prickly ash fruit has the characteristics of small and light growing in clusters. Therefore, the target fruit is obscured by leaves and the shade among fruit clusters is serious, which greatly affects the accuracy of prickly ash fruit image recognition. In addition, some new prickly ash clusters tend to droop and cover the fruit stem and its growing stems, which makes it difficult to accurately locate the picking area. All of these present new challenges to the existing image recognition and picking point determination technology. Aiming at the morphological and growth characteristics ofChinese prickly ash, this paper proposes a method of image recognition and picking point location based on multistage image transformation and cluster growth characteristics of Chinese prickly ash, which provides necessary technical support for the design of a clipping Chinese prickly ash picking robot.

THE REALIZATION PROCESS OF CLUSTER PRICKLY ASH TARGET IDENTIFICATION AND PICKING POINT LOCATION

In this paper, the method of image recognition and picking point location based on multi-stage image transformation and cluster growth characteristics of Prickly ash under natural scenes is implemented in accordance with the process shown in Fig. 1.

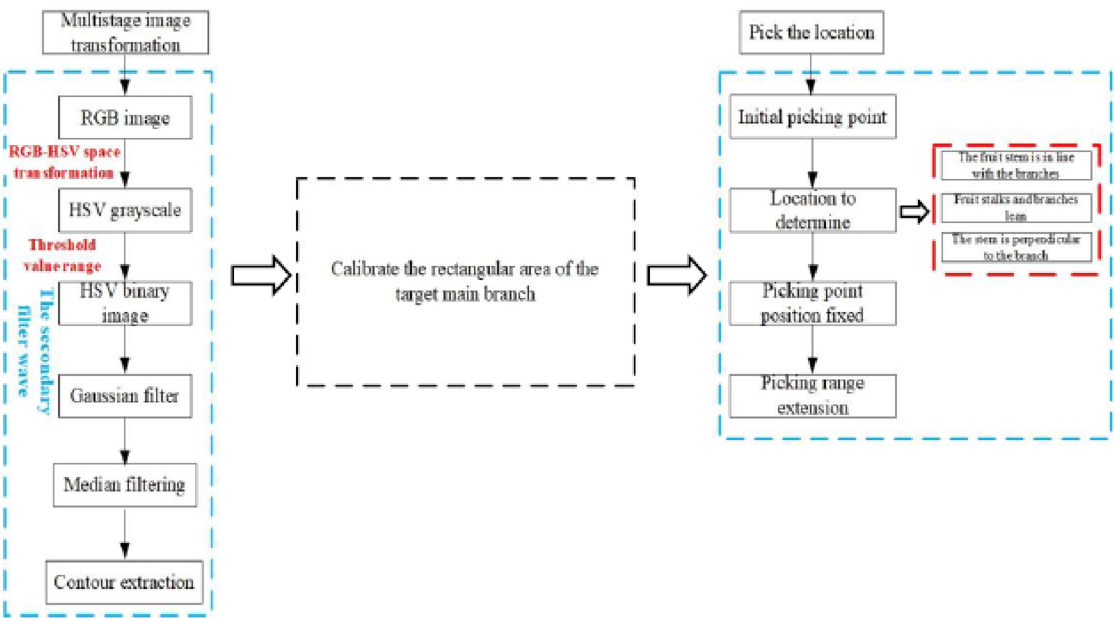


Fig1. *Flowchart of image recognition and picking point location of Prickly ash*

Cluster Pepper Target Recognition Algorithm Based on Multistage Image Transformation

Multistage Image Transformation of Clusters of Prickly Ash Fruit

The transformation from RGB space to HSV space (as shown in Fig. 2(a)) of the original images of Chinese prickly ash collected in natural scenes is based on Equation (1). The function cv2. CVtcolor() in The OpenCV library is called in the Python environment under the Framework of OpenCV. The transformation results are shown in Fig. 2(b). The function cv2.CVtcolor () is used to transform the HSV image into the H component grayscale image (as shown in Fig. 2(c)), and the corresponding HSV-H component histogram is shown in Fig.3. If the graph presents a distinct double peak, one is the background pixel peak and the other is the target area pixel peak, in this case, the gray value corresponding to the lowest point of the trough between the two peaks can be taken as the threshold value, and the cv2.threshold() function is used to binary segment the background region and the target region of the image. If the double peak value of the figure is not obvious, then in the Pycharm development environment, HSV valuers are used to value the typical fruit area of multiple images in the same picking area, so as to obtain the upper limit of the threshold range of HSV, and then the lower limit of the threshold range of HSV is determined according to the HSV color space table[13]. The upper and lower limits of the HSV threshold range are used for binary segmentation of the background region and the target region of the HSV grayscale image by the Cv2.Inrange() function to obtain the preliminary image of prickly ash fruit, as shown in Fig. 4(a).

$$h=\begin{cases} 0°, \text{if } \max=\min \\ 60°\times\dfrac{g-b}{\max-\min}+0°, \quad \text{if } \max=r \text{ and } g\ge b \\ 60°\times\dfrac{g-b}{\max-\min}+360°, \text{if } \max=r \text{ and } g\lhd b \\ 60°\times\dfrac{b-r}{\max-\min}+120°, \text{if } \max=g \\ 60°\times\dfrac{r-g}{\max-\min}+240°, \text{if } \max=b \end{cases}$$

$$s=\begin{cases} 0, & \text{if } \max=0 \\ \dfrac{\max-\min}{\max}=1-\dfrac{\min}{\max}, & \text{otherwise} \end{cases} \qquad (1)$$

$$v=\max$$

Where, Max min represents the maximum and minimum values in the image r, g and b respectively, so h is between 0°and 360°, S is between 0 and 100%, and V is between 0 and Max.

(a) (b) (c)

Fig2. *Prickly ash image :(a) Original RGB image;(b) HSV image;(c) H component grayscale map*

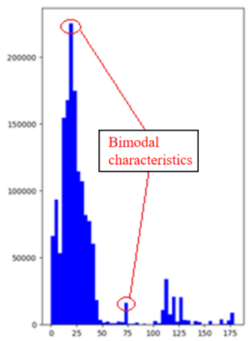


Fig3. *Histogram of HSV-H color image*

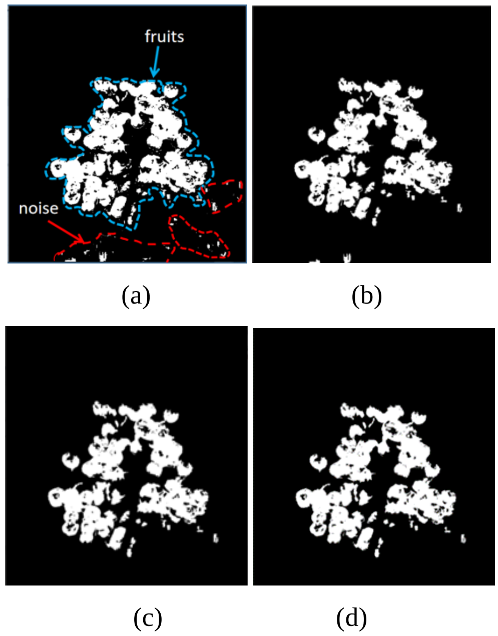


Fig4. *Prickly ash image identified :(a) Preliminary image of prickly ash fruit;(b) Profile after removal of small noises;(c) Contours processed by Gaussian filtering;(d) Contour after median filterin*

Secondary Filtering of Fruit Profile of Cluster Prickly Ash

Although the initial image of prickly ash fruit in Fig. 4(a) retains the target area well, where is much noise, which is not conducive to the determination of fruit cluster contour. Therefore, this section uses the Cv2.findContours() function and walks through the contour with three parameters given the retrieval mode of the binary image contour that needs to be found and the approximate simplified processing method of the contour. Then the contours that meet the conditions are selected based on the length to width ratio and length to width value; Then the drawContours() function is drawn out after removing the small noise as shown in Fig. 4(b). To curb the impact of noise on edge detection, edge of maximum retention and fruit softening outline, this paper adopts the GaussianBlur (src, ksizesigmaX, sigmaY, border Type) function to identify clusters of prickly ash fruit contour level gaussian filtering processing, as shown in fig. 4 (c). In addition, cv2. Medianblur (src, ksize) function was used to perform secondary median filtering processing on the fruit contour of clustered Chinese prickly ash in order to retain some sharp edges on the image and eliminate the influence of white noise, as shown in Fig. 4(d).

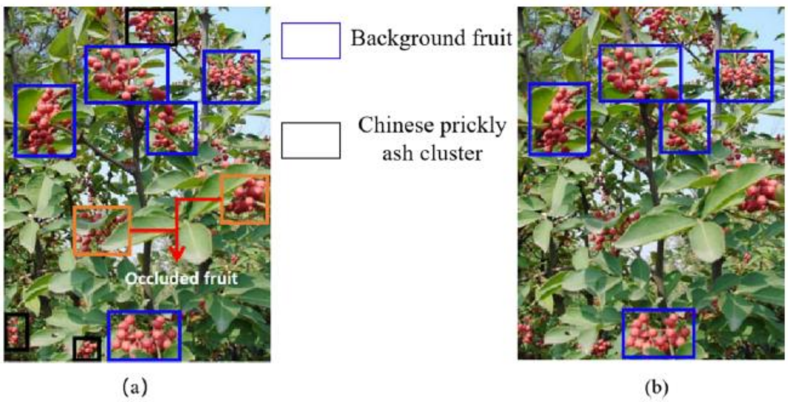


Fig5. *Regional calibration of multi-cluster prickly ash fruits :(a) Original multi-cluster prickly ash;(b) Regional calibration results of multi-cluster prickly ash fruit*

Area Calibration of Clusters of Prickly Ash Fruit

For early treatment of fruit clusters of prickly ash contour image, use the python built-in function enumerate() the largest regional identity, with boundingRect() function to obtain the biggest contour area external rectangular long width direction on the upper left corner and the lower right corner of relevant information, and use function cv2.rectangle (img, (x,y), (x+w,y+h), (0,255,0),5) calibration Rec_1 clusters of Chinese prickly ash fruit contour rectangle (as shown in figure 5 blue rectangle). Then, based on Equation (2), the moment information in the binary image was calculated by using the function Cv2. moments(Contour). According to Equation(3), the barycenter coordinates of the clusters of prickly ash fruits (see the yellow point in the blue box in Fig. 5) were determined, providing a basis for locating the picking points accurately in the next step.

$$m_{pq} = \int\int x^p y^q f(x,y) dxdy, p,q = 0,1,2\cdots \quad (2)$$

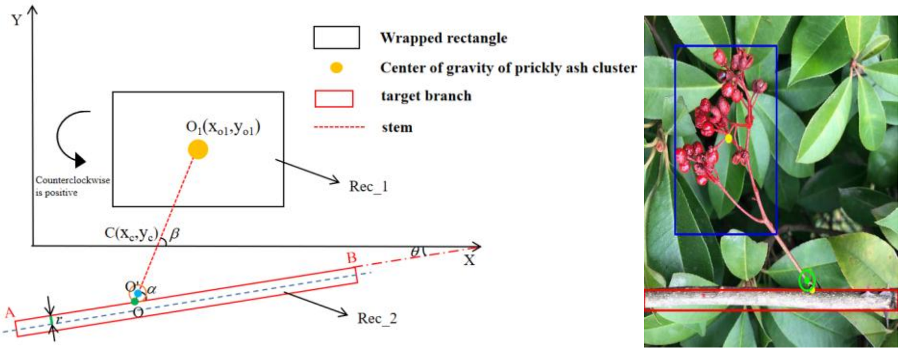
$$x_0 = m_{10}/m_{00}, y_0 = m_{01}/m_{00} \quad (3)$$

Where: m_{pq} is the $f(x,y)'$ $P+Q$ order origin moment of the image gray distribution function, x,y is the horizontal and vertical coordinates of the regional midpoint respectively, x_0, y_0 represents the regional barycenter coordinates

In order to distinguish multi-tufted prickly ash fruit image, the fruit image that may appear in the background branch located far away from the target branch (that is, the background image),clustered prickly ash fruit images that are heavily shaded by nearby leaves (that is, severely shaded fruit images), and the multi-cluster Prickly ash fruit images that are connected into a larger fruit region in the field of vision (that is, connected multi-cluster image of multiple clusters of prickly ash fruit), In order to make the picking location more accurate, In this paper, the average square area S and the sum of squares σwere obtained from all the clusters of prickly ash fruit regions in the image, and then the preliminary demarcated cluster pepper fruit area is judged one by one. If the demarcated area S_i is within the range of $S\pm3\sigma$, it is considered to be a new cluster prickly ash, otherwise, if it is greater than $S+3\sigma$, it is considered that there is connectivity of multiple clusters of prickly ash fruit images, which needs to be resolved, If it is less than $S-3\sigma$, it is considered to be a background fruit cluster or a fruit cluster shaded by branches, and is excluded from the target identification range. As shown in Fig. 5(a), it is the unprocessed multi-cluster prickly ash fruit image, which can be divided into three types: background fruit, The concealed fruit and Prickly ash fruit. After further processing, as shown in Fig. (b), the concealed fruit and background fruit are excluded from the target recognition range, and only the target prickly ash fruit image is retained.

The Picking Location of Prickly Ash Cluster Growth Characteristics was Determined

The method similar to that in Section 3 was adopted to identify and calibrate the target branches within the range of picking targets. The function Cv2. minarearect() was used to obtain the information such as the coordinate width, height and rotation angle of the center point of the minimum enclosing rectangle Rec_2 of the target branches. According to the the directional characteristics of the Rec_1 rectangle (that is, one side is parallel to the X axis and the other side is parallel to the Y axis) , the directional characteristics of the smallest external rectangle Rec_2 of the target branch(that is, the angle between the long side and the X-axis is θ) and the directional characteristics between fruiting peduncle and target branch (the angle is α). In this paper, a picking location determination method based on the cluster growth characteristics of Prickly ash, as shown in Fig. 6 is proposed. The specific implementation algorithm is as follows:



(a) (b)

Fig6. *Method for determining picking locations based on the growth characteristics of prickly ash clusters :(a) Schematic diagram of picking location;(b) Locating result of picking site*

(1) As shown in FIG. 6(a), the acute Angle between the fruiting stem and the target branch is $0<\alpha\leq 2/\pi$, Using Equation(4), the intersection point $C(x_c,y_c)$ between the fruit stalk and the X-axis was obtained, then the direction which the center of gravity point $O_1(x_{o1},y_{o1})$ of the prickly ash cluster connects line $L_{o1,c}$ to the intersection point is the picking direction of prickly ash cluster; If the direction of the line $L_{A,B}$ that defines $A(x_A,y_A)$ and $B(x_B,y_B)$ is the direction of the target branch, then getCrossPrint() function can be used to find the intersection point $O(x_o,y_o)$ of the above two lines, which is the location of the initial picking point. In order to prevent damage to the branches during picking, formula (5) was used to correct the picking point position to $O'(x_{o'},y_{o'})$, and then turtle. Circle () was used to determine the actual picking range of prickle pepper cluster with point$O'(x_{o'},y_{o'})$ as the center and correction coefficient *h* as the radius, so as to enhance the fault-tolerance of the picking location determination algorithm and improve the picking rate.

$$\begin{cases} x_c = x_{o1} - \dfrac{y_{o1}}{\mathrm{tg}(\alpha - \theta)} \\ y_c = 0 \end{cases} \quad (4)$$

$$\begin{cases} x_{o'} = x_o + h\cos(\alpha - \theta) \\ y_{o'} = y_o + h\sin(\alpha - \theta) \end{cases} \quad (5)$$

Where, when the long side of the smallest external rectangle of the target branch rotates counterclockwise relative to the X-axis, the included Angle is positive, while when rotating clockwise, the included Angle is negative. The correction factor *h* is taken as the actual fruiting stem diameter

(2)As shown in Fig. 6(b), the prickly ash cluster ($\alpha=0$) is approximately the same line as the fruiting stem and the target branch. Then, the midpoint of Rec_2, the shortest edge of the target branch, which is closest to the center of mass $O_1(x_{o1},y_{o1})$, is selected as the initial picking point, and then the picking point is modified and expanded in a similar way to that in (1), so as to obtain the actual picking range.

Conclusions

In this paper, a method based on multistage image transformation and cluster growth characteristics of Prickly ash was proposed for image recognition and picking point location in natural scenes, PyCharm2020.1 and OpenCV3.4 were used for programming to achieve the target picking area calibration of cluster prickly ash fruit by multistage image transformation Gaussian and median filtering; According to the statistical characteristics of the demarcated fruit area, the background fruit image in the image which severely obstructs the connected fruit image of multi-cluster prickly ash fruit image was accurately recognized. In view of the growth characteristics of prickly ash fruit, and considering the different growth conditions of prickly ash fruit-stalk and target main branch, a corresponding picking point location method was designed, which has the characteristics of good adaptability, high picking rate and no damage to the branches, etc., and can provide important technical support for the design of pruning prickly ash picking robot.

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