

Application of the Clamping and Positioning System of Vegetable Grafting Machine Based on Machine Vision

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Abstract

In the process of grafting, the vegetable grafting robot needs a gripper to hold the grafted seedlings. Taking the grafting by sticking as an example, the grafting process needs clamping, positioning, carrying and fitting. The gripper in the whole process is related to the success or failure of grafting. In order to better realize the grafting action and improve the intelligence of the machine, this paper proposes the design of grafting seedling clamping system based on machine vision on the basis of the existing grafting robot. Taking the positioning clamping mechanism of the grafting machine as an example, a stable, reliable and high-precision clamping system is studied to improve the grafting efficiency and survival rate.

Keywords

Grafting machine; Machine vision; Clamping mechanism.

1. INTRODUCTION

Japan is the first country in the world to develop vegetable grafting machine, and then South Korea also has relevant reports. As early as 1986, "brain" began the research and development of vegetable grafting robot, and has developed three prototypes. In addition, some private enterprises have also carried out research and development work. The Research Institute of agricultural mechanization of Japan, now known as "bio oriented technology research advanced institution (brain)", has cooperated with agricultural machinery manufacturers to carry out joint research and development. The vegetable automatic grafting machine developed has become a commodity and has been used in agricultural production. The efficiency of the machine is 700-800 trees / hour, and the operation accuracy is 90%. The grafting method is single cotyledon cutting. The grafting machine is mainly composed of a seedling supply part, a control and transportation part, a cutting part, a connecting part, a grafting seedling discharge part and a motion control part [1-3].

The research on grafting technology in China started late, In 1993, Professor Zhang Tiezhong of China Agricultural University first studied the vegetable mechanical grafting, and developed the vegetable grafting device using the inserting method in 1996. In 1998, Professor Zhang successfully developed the 2JSZ-600 vegetable automatic grafting machine (Figure 1). In recent years, Zhejiang Province of China has been committed to developing the grafting equipment that meets the regional agricultural needs, and the research mainly relies on universities and agricultural departments The experimental results show that the prototype can basically complete the grafting operation, but the grafting method and grafting efficiency still need to be further improved.



Figure 1. 2JSZ-600 grafting machine

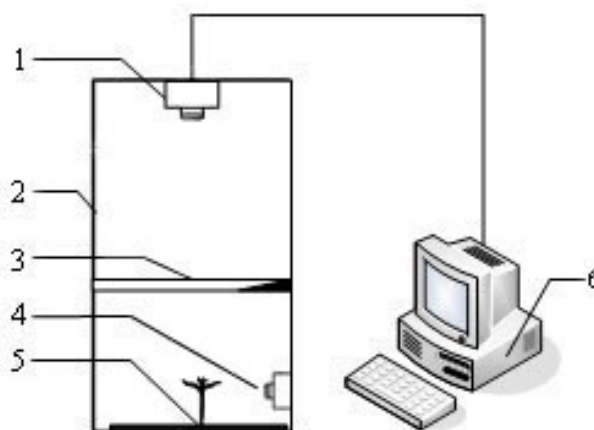
In order to better realize the grafting action and improve the intelligence of the machine, this paper studies the grafting seedling clamping system based on vision for the existing more widely used grafting machine. Taking the positioning clamping mechanism of the grafting machine as an example, the diameter of the grafting seedling is measured by machine vision, and then fed back to the computer, and the grafting seedling is fixed by the clamping positioning mechanism. The quality of grafting was guaranteed by proper position and clamping. The practice shows that a stable, reliable and high-precision clamping system can improve the grafting survival rate and grafting efficiency [4-6].

2. PRINCIPLE AND DESIGN OF MACHINE VISION SYSTEM

2.1. Image Preprocessing

The main function of grafted seedling holder vision system is to automatically detect the stem size and cotyledon rotation angle of grafted seedlings. The system uses VB visual programming software to edit, process the information collected by the camera, calculate the actual stem of the grafted seedlings, and then calculate the step distance of the motor, and issue instructions to drive the motor.

The hardware system of machine vision detection is mainly composed of light source, camera, lens and computer. The machine vision detection system used in this test consists of two cameras, which respectively take the top view and side view of the rootstock (grafting seedling). The camera adopts CMOS color camera of hx-u300 series of Hengxin technology division, and the schematic diagram of the machine vision system is shown in Figure 2.



1. top view camera, 2. light box, 3. light source, 4. side view camera, 5 stage, 6. computer

Figure 2. Image acquisition system

In this experiment, the gray level of the color image is processed by visual software, and then median filtering and threshold segmentation are carried out.

(1) Gray processing

Because the color image takes up a large space, direct processing will cause too much calculation and slow processing speed. Therefore, color image is often converted into gray image before image processing and recognition. The general processing method is weighted average method, that is, according to the importance of R, G, B given different weights, the final gray is RGB weighted and average.

(2) Median filtering

Median filtering is realized by the so-called smoothing filter (divided into linear and nonlinear filters). The effect of smoothing filter in fuzzy processing and noise reduction is obvious. In order to reduce the noise, trivial details and Bridge details in the image are removed before large target extraction. The basic principle of median filtering is to replace the value of a point in a digital image or digital sequence with the median value of each point in a field of the point.

(3) Threshold segmentation

In order to extract the information of stock seedlings in the image, it is necessary to segment the image by threshold. The steps are as follows: through the histogram analysis of gray image, select an appropriate threshold T , and transform the original image $x(I, J)$ into binary image $y(I, J)$ through the following relations:

$$Y(i, j) = \begin{cases} 0 & X(i, j) < T \\ 1 & \end{cases} \quad (1)$$

The binarization effect test is shown in Figure 3, and the stem diameter values of the plants and plants are obtained by scanning along the red line.



Figure 3. Original image and binary image

2.2. Visual System Interface Design

Because the cross-section shape of gourd seedling and watermelon seedling is not round but oval, as shown in Figure 4, the camera collects the measured projection a and cotyledon angle, and analyzes the measured data to obtain the values of long axis and short axis. Therefore, it is necessary to establish a mathematical model to restore the real values of long axis and short axis of grafted seedlings.

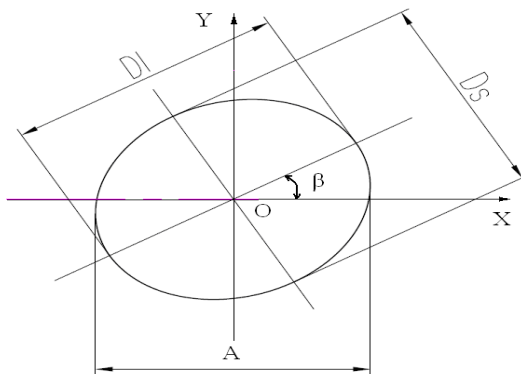


Figure 4. Cross section of grafted seedlings

According to the relationship among major axis, minor axis and ellipticity of ellipse, the values of major axis and minor axis are obtained.

$$D_l = \frac{A}{\sqrt{1 + \frac{\sin^2 \beta + \rho^2 \cos^2 \beta}{(\rho^2 - 1)^2 \sin^2 \beta \cos^2 \beta - (\cos^2 \beta + \rho^2 \sin^2 \beta)(\sin^2 \beta + \rho^2 \cos^2 \beta)}}} \tag{2}$$

$$D_s = \rho D_l \tag{3}$$

In this study, the image size is 1280 x 800 pixels, 24 bit color, saved as BMP file format. The system software is edited by VB platform. The system mainly includes three functions: image acquisition, image processing and calculation results. The system interface (as shown in Figure 5) includes two real-time screen windows, a size comparison diagram and a data area. The side camera and the top camera display the monitoring picture in real time, and the computer collects the picture according to the front signal for processing. At the same time, the software retains the processing results in the format of TXT text, such as seedling stem data, cotyledon expansion angle and other information for statistical analysis after the experiment.

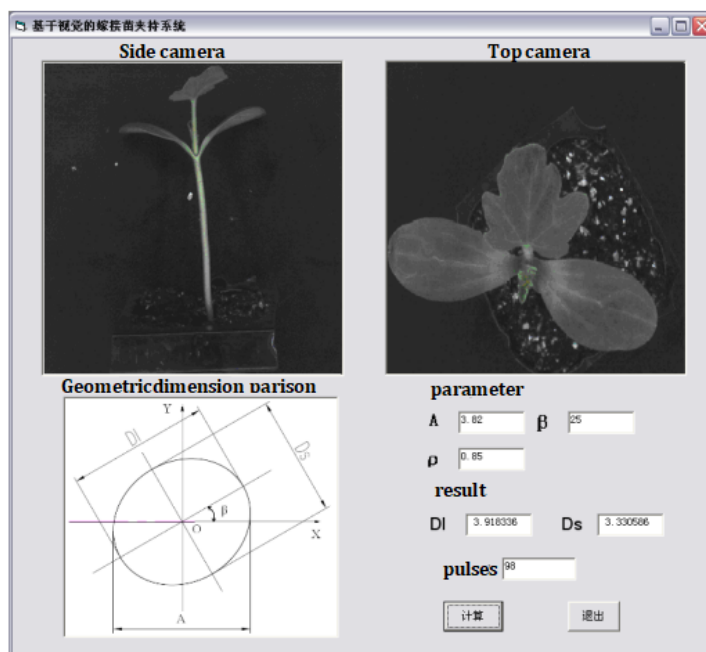
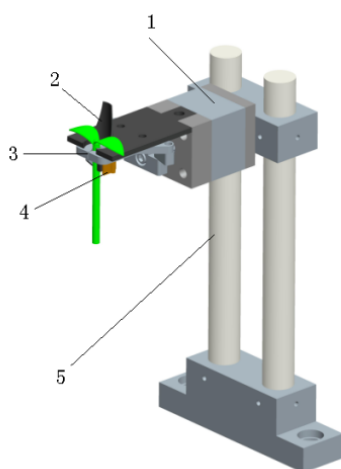


Figure 5. Human computer interaction software interface

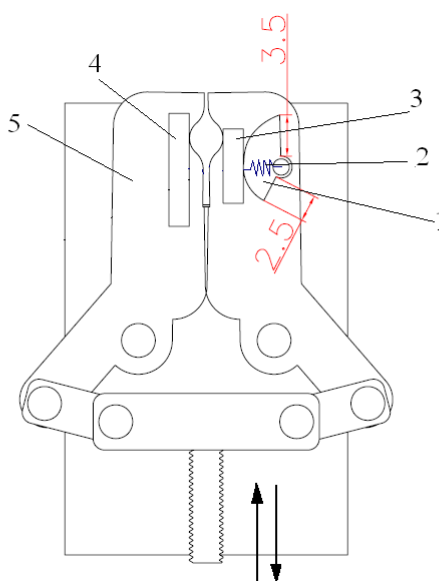
3. DESIGN OF CLAMPING AND POSITIONING MECHANISM OF VEGETABLE GRAFTING MACHINE STOCK SEEDLING

The clamping and positioning mechanism of rootstock seedlings mainly completes the accurate clamping and positioning of the seedlings on the Rootstock to prepare for the subsequent grafting work, and its core mechanism is the clamping device. Like other grippers of grafting machine, as shown in Figure 6, it is mainly composed of sliding guide, macro micro gripper, small camera and adjustable bracket. The main innovation of the slide guide is that it can automatically adjust the direction of the rootstock seedlings. When the seedlings are placed on the slide guide, they will naturally slide along the guide. At the same time, the two cotyledons always keep the same direction, which can not only avoid the complex operation of manually adjusting the seedlings, but also more reliable and accurate than computer vision judgment.



1. cylinder 2. Sliding guide sleeve 3. macro moving claw 4. micro claw 5. support bracket

Figure 6. Clamping and positioning mechanism of rootstock seedling



1. Cam 2. Spring 3. Adjustable plate 4. Fixed plate 5. Macro gripper

Figure 7. Schematic diagram of macro micro gripper

In the grafting work, the traditional clip is designed by using the elasticity of the spring. When it is used to clip the seedlings, it has poor adaptability due to the different stems of the seedlings, and it is easy to hurt the seedlings. Based on these conditions, in order to cooperate with the role of machine vision, this project designs a new macro micro gripper, as shown in Figure 7. The gripper is composed of macro gripper and micro gripper. The macro gripper is driven by the air cylinder along the guide rail and fixed at the positioning hole. There is a very soft cushion on its surface, and there is a gap of 0.1-1 mm between it and the seedling stem, which can protect the seedling stem. The micro gripper consists of a fixed plate, a movable plate, a cam, a spring and a stepping motor. Because the closest point of the cam is 2.5mm, the farthest point is 3.5mm, and the unfolding angle is 144 degrees, the adjustable distance is 1mm. For the stepping motor, the theoretical adjustment can be less than 0.02mm, but the actual adjustment accuracy is 0.05mm. When clamping the seedling stem, the micro gripper is

driven by a high-precision stepping motor.

According to song Yuqiu and others' previous research on the compression characteristics of the plant, according to some research, at the same time, the mechanical properties of the grafted seedlings were tested by WDW-5 electronic universal testing machine controlled by microcomputer. The results showed that the seedling stem would not be injured under 20% pressure. Therefore, we designed the tightening distance parameter of the two clamping plates, which is 80% of the seedling stem. In the process of grafting, we get the diameter of the seedlings, which is photographed by the camera and processed by the computer. Then the computer transmits the information to the PLC, and controls the motor mechanism to adjust the rotation angle according to the diameter of the grafted seedlings, so as to prevent the seedlings from being injured.

4. EXPERIMENT AND CONCLUSION

In order to test the functional characteristics of the vision system and the clamping mechanism, the sample of this study was made up of the rootstock "Zhepu 2", which was cultivated in Zhejiang Academy of Agricultural Sciences during the grafting period. The whole system was composed of machine vision, PLC, stepper motor and cylinder for testing. The results show that the positioning and clamping mechanism of the visual inspection system works stably and runs well, and the damage rate of grafted seedlings is greatly reduced, which meets the requirements of agronomic design.

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