Design of Intelligent Daylily Picking Robot

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Abstract

Daylily as a daily food crop, can significantly reduce serum cholesterol, root, leaves, flowers after treatment can be used as medicine, has a high nutritional value. But the picking conditions of daylily are bad, and long-term picking is likely to cause extremely serious harm to human body, especially to hands. Through the study and summary of the biological characteristics of daylilies, this paper aims to develop a kind of intelligent picking mechanism with strong applicability, The main work includes: designing the binocular recognition system of the intelligent picking mechanism of daylily; Determine the structure type of picking mechanism, and complete the design of the intelligent picking mechanism of daylily.

Keywords: Picking Robot, Daylily, Agricultural, Robot Design, Machine Vision

1. Introduction

As daylily flower planting scale increasing, the traditional manual picking gradually appeared the bad side, one is daylily flower picking very pay attention to detail, early harvest can make the production, because of too much water too late picking and affect mouthfeel, and artificial picking long time consuming and inefficient, easily lead to miss the best harvest time. Second, the cost of manual picking has been rising in recent years. With a great deal of workers pouring into high-earning positions, there is a shortage of labor force for such boring and repetitive work as daylily picking. Third, because the stamen part of daylily contains toxicity, a long time, high frequency of picking will be likely to touch the stamen at the hand part of damage, even skilled farmers are difficult to ensure that the whole body can withdraw.

At present, there is no intelligent daylily picking robot on the market. Based on this, we need an intelligent daylily picking robot that can operate autonomously to realize the automatic operation of daylily picking.

2. Hardware and Software of Control System

The hardware of intelligent daylily picking system consists of three main modules: upper and lower machine, picking arm and sensor. The corresponding functions can be realized by controlling different modules. Overview of control system structure is shown in Fig.1.

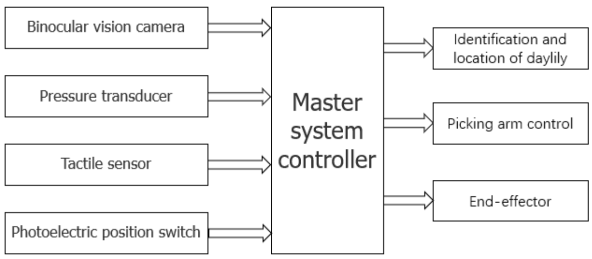

Fig.1 Control system structure

2.1. Control system hardware

The hardware part of the control system needs to have three basic functions: real-time information acquisition, analysis and processing, feedback control. Real-time information acquisition is accomplished by data acquisition and image analysis and processing.

Real-time information data is mainly collected by sensors, and the different signals fed back by pressure sensors and tactile sensors enable the system to locate its position and posture in real time.

Image analysis and processing is mainly through the binocular vision camera to take pictures, and then sent to the master controller of the system, through the algorithm to identify and locate the shape, position and surrounding environment of mature daylily and other useful information.

The feedback control part is realized by the upper and lower computers and internal algorithms and circuits. For example, in motion control, the obtained pose information is compared with the route planned by the master controller to realize real-time motion control.

The output part of the system is composed of controllable steering gear and end-effector. After receiving relevant signals, the manipulator is controlled to move to the specified position and the end-effector is closed to complete the picking. Hardware structure of control system is shown in the Fig.2.

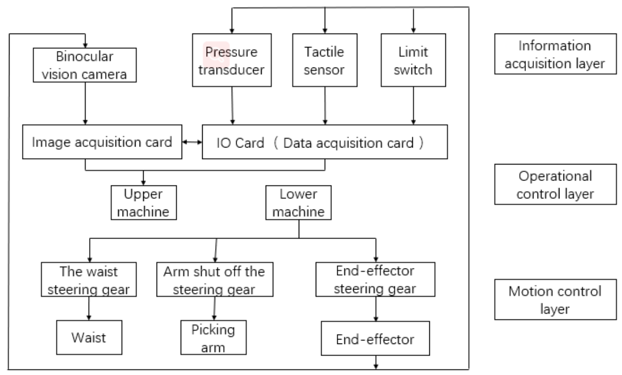

Fig.2. Control system hardware diagram

2.2. Control system software

In the real-time control system of picking mechanism, the control software is divided into host computer and servo controller.

Main functions of host computer: information processing, human-computer interaction, communication, etc.

- Information processing module: process the data transmitted by the sensor, segment and identify the daylily image, locate the spatial coordinates of mature daylily, and plan the picking path.
- Human computer interaction: display the real-time data transmitted by the sensor, display the temperature, humidity, and other states in the current environment, and have a debugging interface.
- Communication module: correct the received pose signal and then transmit it to the lower machine, receive the pose signal of picking arm and end effector and the opening and closing signal of end effector.

Screenshot of some program block diagrams is shown in the Fig.3.

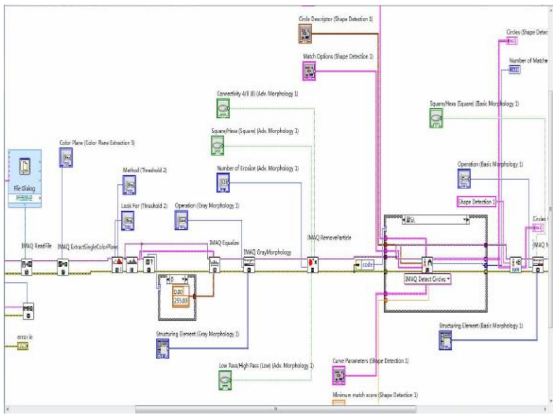

Fig.3. Main program block diagram of binocular vision system

2.3. Work flow of picking mechanism

After the system is started, all equipment will be initialized to ensure the normal operation of the picking arm. Then, the picking robot will complete the three-dimensional coordinate calculation of the daylily on the left side of the robot through the binocular camera and the upper computer, and plan the motion path of the picking arm, control the picking arm to complete the specified action, transport the end effector to the positioned cauliflower [1], close the end effector, realize the clamping and cutting of cauliflower, and complete the picking. Operate continuously until there is no mature daylily within the left visual range. After resetting the picking arm, the robot rotates 180 ° counterclockwise and repeats the previous operation within the right visual range. When there is no mature daylily in the left and right visual range, the picking arm is reset. Workflow of daylily intelligent picking mechanism is shown in the Fig.4.

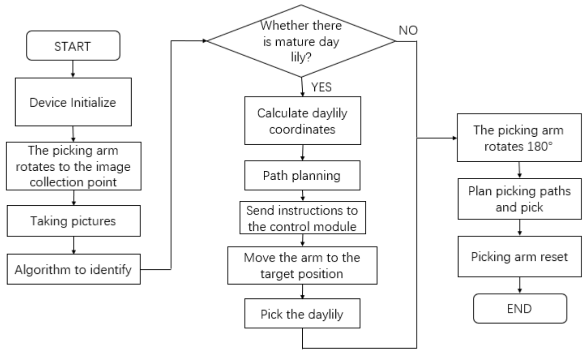

Fig.4. Workflow of daylily intelligent picking mechanism

3. Binocular Vision System Calibration

3.1. Visual system design scheme

The hardware of binocular vision system equipped with intelligent daylily picking robot in this paper is mainly as follows：

(1) A binocular camera that captures images

(2) Image transmission equipment

(3) Industrial computer in charge of image analysis and processing

Fig.3. Binocular vision camera

Binocular stereo camera is shown in Fig.3. The communication mode is TCP/IP protocol or SDK function call interface. The specific parameters are shown in Table1.

Table 1. Main parameters of binocular stereo camera

Parameters of binocular stereo camera	
Model	ZED STERE CAMERA zed2
Camera sensor	1/3“Backside lighting sensor”
Depth frame rate	100FPS
Detection range	20m(3D)；40m(2D)
Output resolution	3840×1080（1080P）
Three high	175mm×30mm×33mm

In this paper, the ZED second-generation binocular camera is selected as the image acquisition equipment. The left and right binocular cameras are coplanar, which fundamentally solves the offset error generated by the left and right cameras when they are installed separately. Binocular vision system construction scheme is shown in Fig.4.

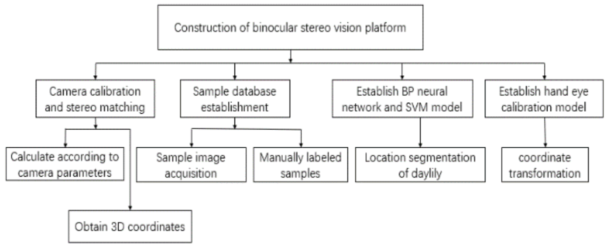

Fig.4. Vision system scheme of picking robot

The ZED2 has a 2μm pixel sensor and a backside light sensor. It has low low-light sensitivity and can collect super clear pictures of daylily for easy software processing [2]. Segmentation localization image of daylily is shown in Fig.5.

Fig.5. Segmentation and location image of daylily

3.2. Binocular camera calibration

For the intelligent cauliflower picking robot, after the threshold segmentation of the cauliflower image, the left and right cameras must be calibrated before calculating the spatial three-dimensional coordinates of the mature cauliflower. Because the binocular camera is used, binocular stereo calibration is also required.

- Stereo calibration of binocular camera

In order to calculate the spatial coordinates of mature daylily, it is necessary to establish the geometric model of camera imaging for the left and right cameras, which is to calibrate the left and right cameras [3]. The transformation matrix of two camera coordinate systems consists of a 3×3 rotation matrix R and a translation vector T. Located in the world coordinate system, the P coordinate of a point in space is (X_w, Y_w, Z_w), The abscissa of the imaging points of the left and right cameras is (X_l, X_r). The relationship between the rotation matrix from the world coordinate system to the camera coordinate system $(R_l,\ R_r)$, Translation vector from world coordinate system to camera coordinate system $(T_l,\ T_r)$ and Spatial coordinates(X_w, Y_w, Z_w) can be expressed as:

$$\begin{cases} X_l = R_l X_w + T_l \\ X_r = R_r X_w + T_r \end{cases} \tag{1}$$

Order $R = R_r R_l^{-1}$, $T = T_r - RT_l$. The simplified formula (1) can be obtained:

$$X_r = RX_l + T \tag{2}$$

- Remote AR registration method

There is a remote AR registration method in which the virtual robot coordinate system coincides with the physical robot coordinate system, which is an efficient and cheap human-computer interaction method based on RGB-D imaging and attitude teaching device. Through human-computer interaction, the local operator can effectively complete the trajectory planning of the remote robot (including the path planning and attitude planning of the robot end effector) [4].

4. Conclusion

In this paper, the rationality and practicability of the structure of cauliflower intelligent picking mechanism still need to be further verified. At present, the cauliflower picking robot is still in the design stage. The follow-up research work is to make the first generation of picking robot, and then carry out model training and simulated picking of cauliflower in the laboratory. After the success rate reaches a certain degree, select the flat area for natural picking in the field, and make version changes according to the actual situation, Finally, an intelligent picking robot that can participate in the actual production will be formed.

References

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Authors Introduction

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He received his Bachelor of Engineering degree from the school of Electronic Information and Automation of Tianjin University of Science and Technology in 2021. He is acquiring a master's degree in engineering from Tianjin University of Science and Technology.