SUGISAKA MASANORI

Journal of Advances in Artificial Life Robotics
Vol. 3(3); December (2022), pp. 135–138
ON LINE ISSN 2435-8061; ISSN-L 2435-8061
https://alife-robotics.org/jallr.html

Research Article

Design of Control System for Daylily Picking Robot Based on Binocular Vision

Jiaxin Li, Zhuning Liu, Min Zhao
College of Electronic Information and Automation, Tianjin University of Science and Technology, 300222, China

ARTICLE INFO

Article History

Received 22 November 2021
Accepted 27 October 2022

Keywords

Picking robot
Daylily
Agricultural robot design
Machine Vision

ABSTRACT

Daylily is loved by people because of its unique nutritional value, but because of its unique biological characteristics, the harvesting environment of daylily is poor, and the long-term harvesting may cause certain injuries to the workers' hands. This paper aims to develop a picking robot with strong applicability by studying and summarizing the biological characteristics of daylily, which can accurately identify the picking parts through binocular recognition system and complete the intelligent picking process of daylily.

1. Introduction

The picking conditions of daylily are bad, and long-term picking is likely to cause extremely serious harm to the human body, especially to the hands. Through the research and summary of the biological characteristics of daylily, this paper aims to develop an intelligent daylily picking robot with strong applicability. The main work includes: the design of binocular recognition system for quick segmentation and recognition of daylily; Workflow design of intelligent daylily picking robot; Software and hardware design of daylily picking control system.

2. Design of Binocular Recognition System

2.1. *Visual system design scheme*

The construction of binocular stereo vision platform consists of three parts [1]. First, establish a sample database to discover which data are more important and which data are not particularly important, so as to further optimize the picking speed and accuracy; Second, BP neural network and SVM model are established to facilitate the localization and segmentation of daylily in the collected pictures; Third, the fixed hand eye calibration model based on genetic BP neural network is established to facilitate the subsequent coordinate conversion.

Binocular vision system construction scheme is shown in Fig.1.

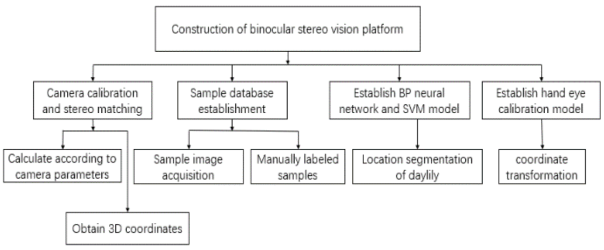

Fig.1. Vision system scheme of picking robot

Corresponding author's E-mail: 790861600@qq.com: web: www.tust.edu.cn

2.2. ***Identification of overlapping daylily target Fruit***

To identify overlapping daylily, firstly, noise filtering is carried out on the original image to remove the salt-and-pepper noise in the original image, and then the improved maximum class variance method (OTSU) [2] is used to identify overlapping daylily, and then the K-means clustering algorithm is adopted to cluster the pixel region of the overlapping target. The location of a single daylily was determined by extracting the light-receiving part of the image. The approximate region of the target boundary of a single daylily was obtained by combining the analysis and growth of the connected region. Finally, the exact boundary of the target daylily was obtained by the watershed algorithm.

The flow of target fruit recognition and boundary segmentation algorithm of overlapping Daylily is shown in Fig.2.

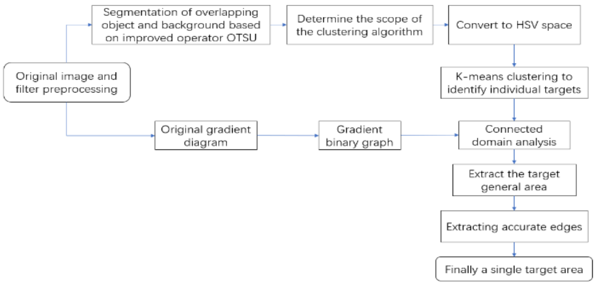

Fig.2. The flow of boundary segmentation algorithm

2.3. ***Image processing***

The collected images are preprocessed. Firstly, gray scale processing, cutting and size normalization are carried out to obtain preliminary image data. Then the image is corroded and expanded so that the edge can be recognized more accurately [3]. Edge recognition picture is shown in Fig.3.

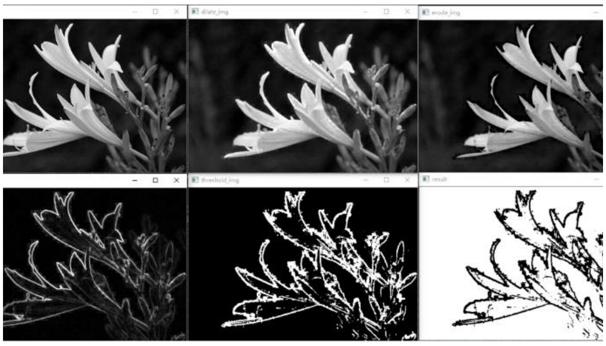

Fig.3. Morphological processing and edge recognition

After that, features are extracted and the model is obtained by deep convolutional neural network. Finally, the information collected in real time is processed and output to the recognition model, so as to achieve the purpose of identifying the maturity and positioning the spatial position of daylily [4]. Daylily positioning image is shown in Fig.4.

Fig.4. Segmentation and location image of daylily

3. Work Flow and Hardware Design of Picking Robot

The control system of picking robot is mainly composed of upper and lower computer controller and sensing system. The control system adopts the upper and lower computer two-layer structure, and the lower computer controller includes: end-effector controller, manipulator controller and moving platform controller. The manipulator controller is connected to the upper computer controller for communication. The sensor converts the collected pressure, tactile and optical signals into electrical signals and sends them to the general control system. After analysis and processing, the control system controls the position and speed of scissors closure and opening through the end-effector. Overview of control system structure is shown in Fig.5.

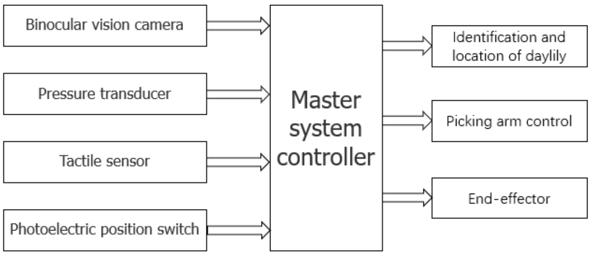

Fig.5. Control system structure

3.1. *Control system software*

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

The main functions of the main computer include the following parts: data processing, human-computer interaction and information 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.

3.2. *Mechanical arm design*

The intelligent robot has two complete sets of picking subsystems, which are relatively independent from each other, and can carry out the picking work at the same time to improve the picking speed. For each picking subsystem, its hardware composition is as follows [5]:

- Parallel manipulator: The mechanical arm can control the rotation of the bottom platform in the horizontal and vertical directions, and always keep the bottom platform in the horizontal position.
- Picking module: The picking module is composed of a mechanical grab and a mechanical scissors, which is installed at the bottom of the parallel manipulator. The mechanical scissors can cut the root of the daylily, and at the same time, the mechanical grasp can fix the daylily.
- Storage platform: boxes and sacks can be installed to store the picked daylily.
- Horizontal guide rail: The top of the control arm reciprocates greatly in the horizontal direction, and the position of the top of the parallel manipulator can be precisely controlled. Make the parallel manipulator close to the daylily or the platform to be picked.
- Vertical guide rail: The top of the control arm reciprocates greatly in the vertical direction, and the vertical position of the top of the parallel manipulator can be precisely controlled. The whole system can better adapt to picking daylily of different heights.

System hardware structure diagram is shown in the Fig.7.

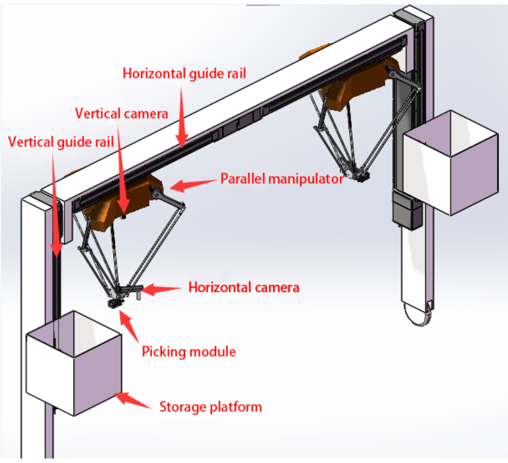

Fig.7. System hardware structure diagram

3.3. *Work flow of picking mechanism*

Step 1: The parallel manipulator rises vertically to the highest point and moves horizontally to the middle of the equipment.

Step 2: The vertical wide-angle camera finds the horizontal position of daylily.

Step 3: Process the image and calculate the horizontal position of daylily

Step 4: The mechanical arm moves to the horizontal position of the daylily.

Step 5: The mechanical arm continuously slides downward and vertically, while the horizontal camera judges the separation position of the root and leaf of daylily in real time.

Step 6: When the horizontal camera judges that the mechanical scissors have been located at the bottom of the daylily, the mechanical scissors are closed to cut the daylily, and the mechanical claw grasps the daylily at the same time.

Step 7: Move the mechanical arm to the storage platform.

Step 8: The mechanical claw of the picking module is released, and the daylily falls into the material holding platform. Then return to the first step and restart the picking process.

Workflow of daylily intelligent picking mechanism is shown in the Fig.8.

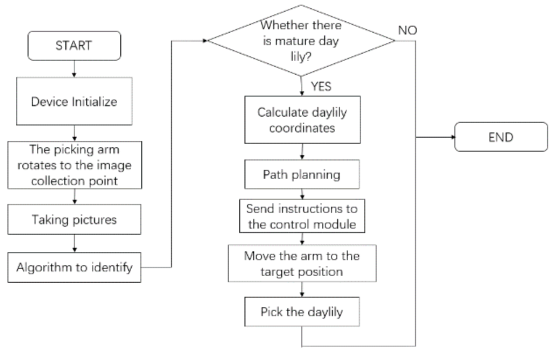

Fig.8. Workflow of daylily intelligent picking mechanism

4. Conclusion

This paper studies the motion control of the picking robot and the recognition and positioning method of the target fruit of daylily, and designs the methods and ideas on the recognition and positioning of the target fruit. However, due to the limitation of time and insufficient experimental conditions, it is still necessary to conduct further research on some work, such as the maturity analysis of overlapping daylily, the recognition of daylily under severe occlusion, and the trajectory planning when there are spatial obstacles in the working space.

References

1. Xiangjun Zou,Haixin Zou & Jun Lu. (2012). Virtual manipulator-based binocular stereo vision positioning system and errors modelling. *Machine Vision and Applications*(1). doi:10.1007/s00138-010-0291-.y.
2. Y. Ramadevi et al. (2010). Segmentation And Object Recognition Using Edge Detection Techniques. *International Journal of Computer Science & Information Technology*.
3. Lane A. Hemaspaandra et al. (2005). Cluster Computing and the Power of Edge Recognition. *CoRR*.
4. Weikuan Jia et al. (2020). Detection and segmentation of overlapped fruits based on optimized mask R-CNN application in apple harvesting robot. *Computers and Electronics in Agriculture*(C). doi:10.1016/j.compag.2020.105380.
5. Kim Jungyeong. (2019). Design and Implementation of 3DoF Manipulator with Cable-Hydraulic Driven Actuation for Cooperative Robot with High Output and Low Inertia. *Journal of Korea Robotics Society*(3). doi:10.7746/jkros.2019.14.3.179.

Authors Introduction

Mr. Jiaxin Li

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.

Mr. Zhuning Liu

In 2022, he received his Bachelor of Engineering degree from the School of Electronic Information and Automation, Tianjin University of Science and Technology, China. He is pursuing a master's degree in engineering from Tianjin University of Science and Technology.

Ms. Min Zhao

She is a master student in Tianjin University of Science and Technology. Her research is about automatic and adaptive control.