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Structural Design of Mushroom Picking Robot

Heng cheng WU, Yichen GUO, Ting ZHANG
School of Mechanical and Automotive Engineering, Shanghai University of Engineering Science, Shanghai, China

Abstract
The annual consumption of mushrooms in China has been increasing year by year, and the cultivation mode has also shifted from a single family-based approach to a factory-style, intensive mushroom shed cultivation mode. With the growth of the mushroom market demand, issues such as high-intensity harvesting requirements and the gradual shortage of labor have become prominent. This paper focuses on mushrooms and designs a smart mushroom harvesting robot, utilizing flexible grasping and visual recognition technologies, to provide a practical and feasible solution for mushroom harvesting.
Keywords: *Agaricus bisporus; intelligent harvesting; harvesting robotic arm; visual recognition.*

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I. INTRODUCTION

At present, the research on intelligent picking mostly focuses on picking vegetables and fruits. For example, Naoki et al. Use the camera image area change to determine vegetables and fruits, and improve the success rate of vegetable and fruit robot [1]. Irie et al. Developed an automated asparagus picking and collecting robot to replace manual labor [2].

USN Rao uses machine vision, image processing and microcontroller to recognize and process Cotton images, and uses mechanical arm to pick cotton [3]. Christopher Lehnert et al. Proposed a method of harvesting sweet pepper automatically by using manipulator [4].

Vegetable and fruit picking mainly focuses on how to adjust the posture of the robot hand according to the image information, improve the success rate, and use multiple end effectors. Relatively speaking, there are few studies on mushroom picking. Ji, et al. [5] Designed a flexible profiling picking end of Agaricus bisporusto solve the problems of high mechanical damage and large picking loss caused by the existing clamping picking manipulator. Cheng [6] designed a kind of end effector of bisporus mushroom picking manipulator to solve the problem of low efficiency of bisporus mushroom manual picking.

II. THE OVERALL STRUCTURE DESIGN

The overall structure of the intelligent mushroom picking robot is composed of five parts, as shown in Figure 1. They are the four-wheel track walking mechanism, the rectangular coordinate motion mechanism, the flexible grasping mechanism with integrated visual recognition function, the mushroom storage mechanism with integrated loading and unloading, and the mechanism with output. The four-wheel track walking mechanism enables the mushroom picking robot to move horizontally between the planting layers of the mushroom shed, increasing the mushroom picking area. The rectangular coordinate motion mechanism is connected above the four-wheel guide rail travel mechanism by a connecting plate to realize the movement of the picking machine flexible gripper mechanism on the XY plane.

The flexible grabbing mechanism with integrated visual recognition function is fixed on the Cartesian coordinate motion mechanism, and its holding radius is adjustable to meet the grabbing of mushrooms of different sizes. With the help of visual recognition technology, it can complete the classified picking of mushrooms of different sizes. The integrated mushroom storage box is fixed on the outside of the four-wheel guide rail walking mechanism by a hook. The harvested mushrooms enter the storage box through the conveyor belt. When the mushrooms reach a certain weight, one end of the storage box will automatically open and put the mushrooms in the box into the packing bag.

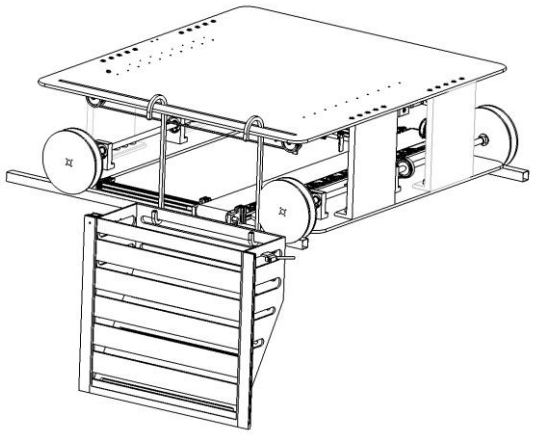

Fig. 1 Schematic diagram of intelligent mushroom picking robot

III. STRUCTURAL DESIGN OF MUSHROOM PICKING ROBOT

3.1Picking structure design

The picking structure is composed of symmetrical moving pairs, rolling high pairs, sliding rails and claws. It can realize multi-directional mobile picking to pick the target mushroom. After calculating the coordinate position of the mushroom in line with the picking, the coordinate position information is communicated to the multi axis motion mechanism software system in real time. The height movement of the X and Y axes drives the grabbing mechanism to move. When it is above the mushroom position, the Z axis moves to the appropriate position above the mushroom in combination with the height information, and the grab is rotated. Because the traditional metal rigid gripper can not effectively protect the mucus film of mushroom, and the humidity of mushroom planting environment is high, it is easy to rust the metal gripper and motor.

Therefore, the robot flexible picking gripper based on humanoid picking action is independently developed to carry out nondestructive and efficient picking of delicate and vulnerable flexible mushrooms. Through the experiment, the design parameters such as the minimum gripping force, destruction gripping force and the shortest and longest length of the manipulator when the mushroom is completely wrapped are obtained. The structure of the end flexible picking gripper is designed according to the picking method, environment and materials used.

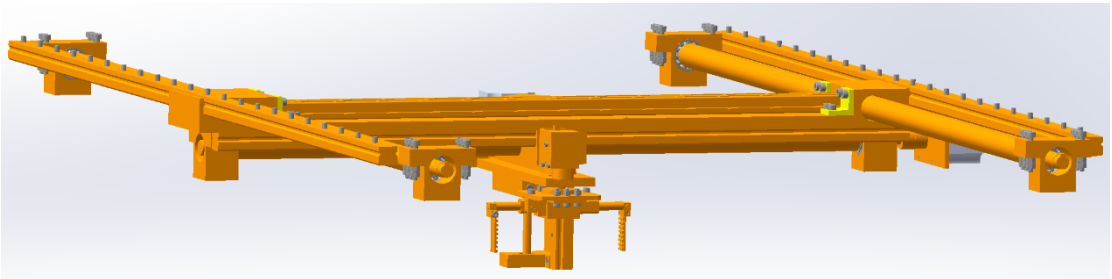

Fig. 2 Schematic diagram of picking device

3.2 Transmission structure design

The conveying structure is composed of a conveyor belt, which can transport the mushrooms picked by the picking device to the ready collection device. The front wheel of the conveyor is used as the driving wheel, and the electric control motor distributes the power to drive the whole plane. At the same time, considering the soft nature of mushrooms and the moist and humid conditions in the mushroom culture environment, in order to not damage mushrooms and extend the service life of the conveyor belt, rubber with the advantages of elasticity, wear resistance, moisture resistance and so on is used as the conveyor belt. Because the robot needs to constantly change its position on the guide rail during the picking process, the transmission structure is connected to the tracks on both sides, and the rotation data of the transmission structure and the robot motor are used as input data to solve the problem of synchronous movement between the transmission device and the robot by studying the motor speed and algorithm. Since the conveyor is under the picking device, there is a problem of occupying the picking space, so communication should be used to enhance the synchronization rate between the conveyor and the picking device in the design process.

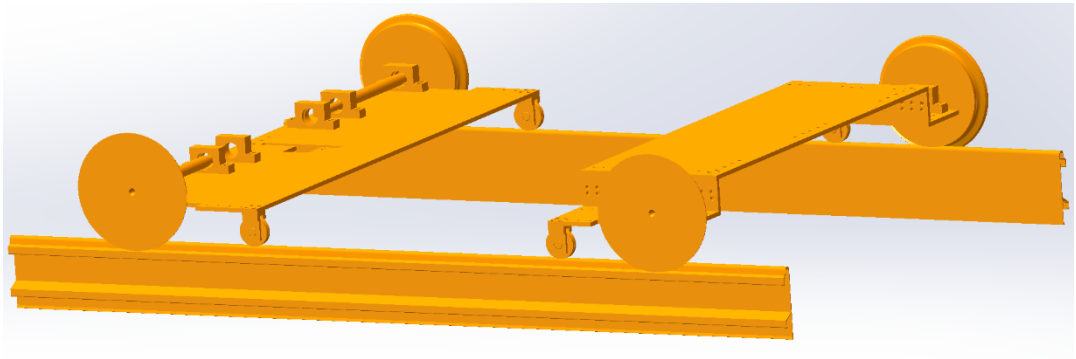

Fig. 3 Schematic diagram of conveyor

3.3 Collection and weighing structure design

The collection structure is composed of hollow thin-walled containers. The mushrooms transported by the conveyor can be collected in the container, and the weight is calculated by the internal weighing device. When the weight reaches a certain value, the baffle lifts the mushroom and falls. By studying the maximum and minimum diameters of mushrooms under mature conditions, the volume interval of mushrooms is calculated to design the volume and volume of the collection device, enough internal space is reserved to install the weighing device, and the motion trajectory of the baffle is designed according to the actual use.

The structure of the storage box is shown in Figure 4. The storage box structure includes several components such as hooks, inclined plates, baffles, and hoardings. Among them, the number of hooks is two, the upper end is connected with the upper roof, and the lower end is connected with the coaming, which mainly plays the role of support and support. An inclined plate is fixed at the lower end of the shroud to prevent mushrooms from falling from the mushroom collection mechanism. The shroud is also equipped with a baffle, which is used to regulate the flow of mushrooms and prevent blockage.

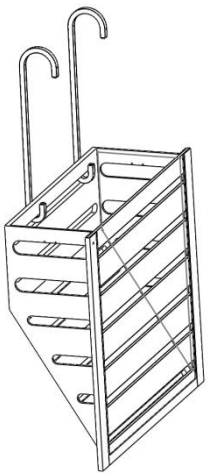

Figure 4 structural scheme of storage box

IV. CONCLUSION

This project combines the track movement and Cartesian coordinate movement, uses visual recognition and flexible grasping technology to complete the classification and picking of mushrooms of different sizes, uses the conveyor belt to complete the transportation of harvested mushrooms, and uses the portable storage box to complete the collection, bagging and packaging of mushrooms, and finally realizes the whole process of automatic and intelligent picking of mushrooms.

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