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## Design of a Fruit and Vegetable Picking-Used Manipulator

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### Abstract

The fruit and vegetable picking-used manipulator is the automatic control system of automatic picking and collecting of fruits and vegetables. This topic main research problem is cucumber identification and picking system, under the condition of guarantee harvest the fruits and vegetables condition as part of the work efficiency, machine vision plays a vital role in the whole picking system. since the fruit and vegetable picking-used manipulator belongs to agricultural products, it needs to meet the requirements of easy operation and easy to handle and reasonable product cost.

### Keywords

Picking-used, Machine vision, manipulator, SCM.

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## 1. Introduction

During the whole production process of fruits and vegetables, picking work occupies as much as 40% workload. But with the development of society, a series of factors, such as labor reduction caused by aging of population, have led to the increase of agriculture production cost, so fruit and vegetable picking-used robot is an important research project for agricultural automation production. Intelligent robots are becoming more and more popular in many fields along with the society development[1-2]. Agricultural robot is also used in the whole production process of agriculture, and promotes the agricultural production to develop towards mechanization, automation and intelligence. In this research, the control system of a cucumber picking robot is studied and designed, so as to achieve the goals of increasing productivity, reducing production costs and liberating labor productivity[3].

Fruit and vegetable picking-used robot is greatly different from robots used in other fields, such as the industrial robot and exploration robot, because fruits and vegetables are more tender and have complex appearances and some individual characteristics, no damage should be made in the picking process. Moreover, fruits and vegetables grow randomly, their living environments are rather complex with external interference, which increase the difficulty of picking. All these problems should be solved with a lot of experiment researches, so it's impossible to popularize the picking-used robot at present[4-5]. This design is mainly about the control system of cucumber picking manipulator, different parts of the robot are also designed according to current technology.

In this design, images are recognized and processed with Pixy CMUcam5 image recognition sensor, the processed data are uploaded onto Arduino single chips, then the programs compiled according to Arduino IDE are used to control picking operation of manipulator. This part mainly concerns the

design of mechanical components. Picking-used robot controls the rotation and translation of components through the steering engine, so as to implement basic functions. Design flow chart of the robot's system structure is shown in Figure 2.1. In the flow chart, the single chip firstly sends a recognition order to the image sensor, the sensor recognizes the color and then feeds back the signal to single chip. Next, the single chip controls four steering engines to respectively control the body rotation, translation of main arm and forearm, opening and closing of mechanical grippers. Thus, whole operation system of the robot is formed.

## 2. Body Design

The body is a structure connected to the arm, it's also the support structure of the whole robot. Apart from supporting the arms, the body can also implement basic functions, such as rotation, lifting and descending, pitching. In this design, the robot is a manipulator and it's only required to complete basic rotation movement. Based on a thorough understanding of the body design and to better realize its functions of rotation and supporting, the body is designed into a cylinder shape with four brackets added on the base to fix the entire body and increase the robot's stability. Three-dimensional sketch of the body is shown in Fig.1.

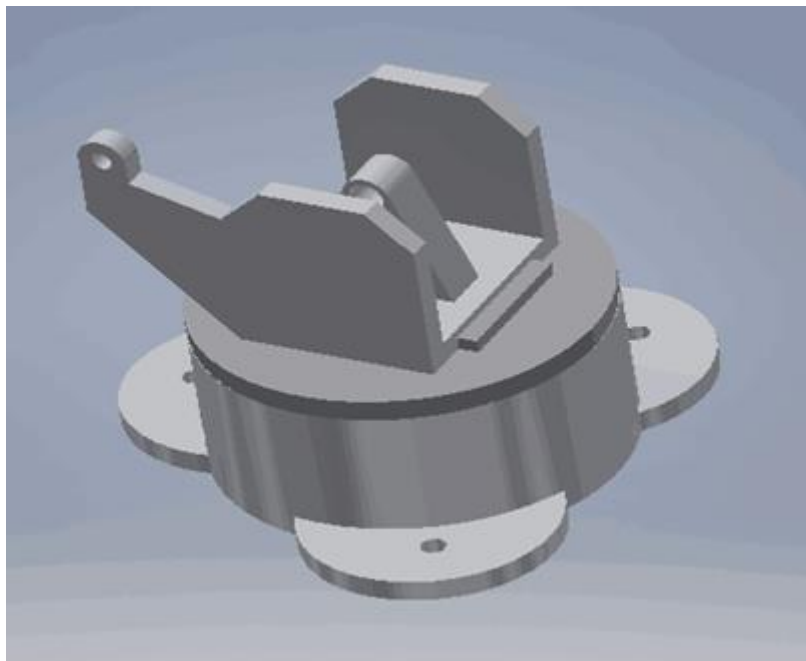


Fig.1 Three-dimensional sketch of body

## 3. Arm Design

To achieve the desired effect, the robot in this design needs a structure consisting of a main arm and a forearm. Each arm has a two-degree-of-freedom, the main arm is mainly responsible for the expand and contract of the manipulator while the forearm is responsible for the lifting and descending of the manipulator. In the design of the manipulator's arms, following parts are involved:

- (1) As the main support mechanism of target object, the arm should be designed with enough rigidity to guarantee its load-bearing capacity.
- (2) To avoid interference between different parts of the manipulator arms caused by relative movement, arm extensions in square-shaped or spline-shaped shall be designed.
- (3) To improve the working speed and efficiency of the manipulator, the arm weight shall be reduced as much as possible, so as to reduce total moment of inertia of the rotating body. Meanwhile, the arm's centre of gravity shall be close to center of the body, so as to avoid dead lock in the arm's lifting and descending caused by excessive torque.

(4) To realize high precision and stable operation for the manipulator, the arm should be compact and light, buffer measures are also required for the arms.

Three-dimensional sketch of the arm is shown in Fig.2.

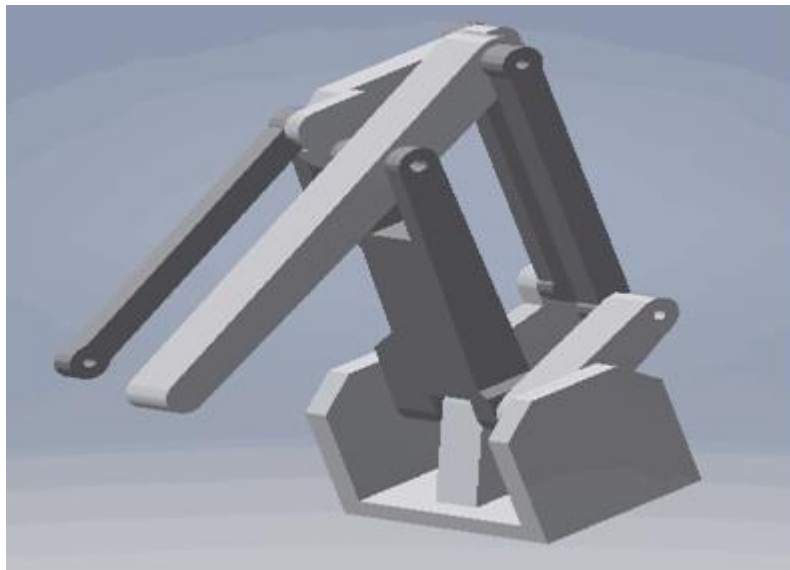


Fig.2 Three-dimensional sketch of arm

#### 4. Wrist Design

The manipulator's wrist is connected with the gripper and the arm, its main function is to support the gripper. Degree of freedom of the wrist determines its position and posture in the space, it's required to realize a rotation of X, Y, Z coordinate axis, that means it shall have three degrees of freedom of rotation, pitching and deflection. Such a wrist can complete more complex movements, however, the wrist in this design has single degree of freedom, it can avoid obstacles and grasp objects through rotation. In this design, the wrist is required to rotate flexibly and its rotation angle is required to be  $180^\circ$ . Three-dimensional sketch of the wrist is shown in Fig.3.

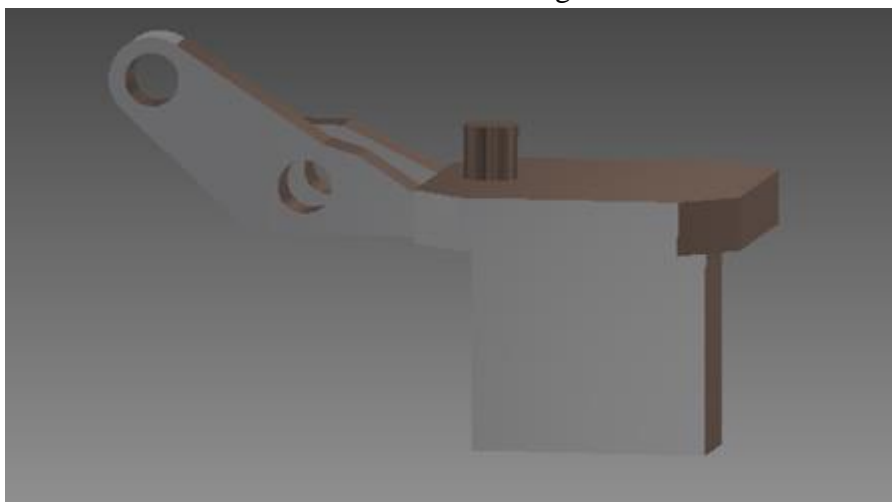


Fig.3 Three-dimensional sketch of wrist

#### 5. Gripper Design

Generally, gripper is a special equipment, different workpieces shall be grasped with different grippers. Therefore, parameters of the target object shall be collected in designing the gripper, such as the weight and diameter, thus designing a special gripper.

Target object for this design is the cucumber, so the opening and closing angle, grasping force shall be noticed in design. By analyzing basic data (length, diameter and weight) of most mature cucumbers, conclusions are obtained as follows: weight of a mature cucumber is generally 300--500g, the length is generally 27--30cm and the diameter is 4--7cm. With these data, limited opening and bearing capacity of a gripper can be designed.

Three-dimensional sketch of the gripper is shown in Fig.4.

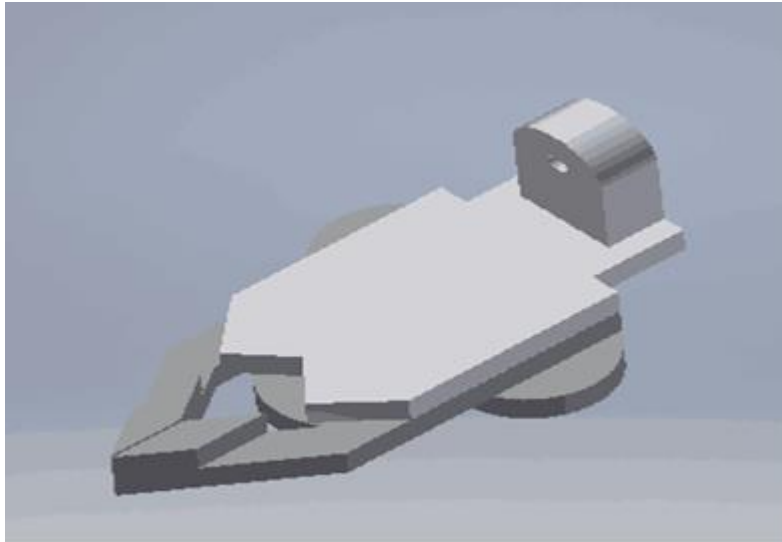


Fig.4 Three-dimensional sketch of gripper

## 6. Control System Design

Control system design is the key part of the robot, its main function is to control the robot to complete various operations according to the compiled commands. When designing a control system, common control panels shall be understood and commands can be written into the control panel to control mechanical system. This design is about a cucumber picking-used robot, it's required to recognize target cucumbers with visual location system in control system design, then to feed the information back to the control panel. The control panel controls the manipulator to pick cucumbers according to commands while the visual location system determines the space location of cucumbers, so as to ensure the manipulator to find picking location accurately.

## 7. Conclusion

The whole manipulator mainly consists of body, main arm and forearm, wrist and gripper. A fix base is designed at the bottom of the body, so as to make the manipulator works more stably. The connection rod connects both main arm and forearm to form a link mechanism. During the picking process, the manipulator operates corresponding movements under control system, all parts work together to find the picking location, and picking is completed through rotating the body, adjusting the distance and height of main arm and forearm, opening and closing of the gripper. Finally, picked fruits and vegetables are moved to specified position.

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