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Adaptive Mechanical Jaws Based on Underactuated Systems

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Abstract: *In the traditional fruit industry, farmers have a lot of fruit to pick in a short period of time when the harvest season approaches. They had to hire additional labor during the harvesting season because the fruit needed to be harvested accurately and quickly. But the additional cost of hiring seasonal workers puts more burden on farmers, especially during the COVID-19 outbreak. Therefore, this paper designs a robotic gripper with an arm and adaptive fingertips. The flexibility of the gripper allows it to grasp fruits of any shape and size without dropping or causing any deformation. In addition, motors and wheels can be added to the base of the arm and moved to the next tree. Using Arduino Nano as the controller, the device can use APP to achieve wireless Bluetooth control, easy to operate. The mechanical claw is driven by a three-jaw structure with only a single drive and adaptive function to complete the gripping action, and the mechanical claw is driven by a screw motor. The device also has two degrees of freedom, relying on two electric actuators to provide lifting action. The mechanical jaws have a human wrist-like rotation effect and can imitate the human hand when picking fruits.*

Keywords: *Arduino; Underactuated Systems; Fruit picking*

1. Introduction

The end-effector is an important part of the fruit picking robot and is set at the front end of the robot. The actuator is often in direct contact with the picking target during the picking operation. Due to the complexity of the fruit picking environment and the picking target, the design of the end-effector is usually considered as one of the core technologies solution design for agricultural robots.

Currently developed fruit-picking robots can generally only pick for one kind of fruit if each species must be used for special picking equipment. Not only is the usage rate low, costly, and expensive, but it is also not conducive to commercialization. In this paper, a general-purpose adaptive precursor robot is designed, which can automatically complete the grasping according to the size of fruits.

2. Program design

The Bluetooth module is used to obtain the user's command, and the Arduino Nano is used to control the motor and servo to complete the corresponding action, which makes the robot touch the fruit and complete the fruit picking. The actuators include an electric actuator, screw motor, and servo.

2.1. Functional details

2.1.1. Adaptive mechanical jaws

The mechanical jaws are based on the Underactuated Systems design. The power source is only a screw motor, which drives the slider up and down through the rotation of the screw, driving the mechanical jaws to work, and the individual jaws are composed of a multi-link structure. Therefore, when encountering a regular surface, the mechanical jaws can fit perfectly with the surface of the object, increasing the contact area and reducing damage to the object, as shown in Figure 1.

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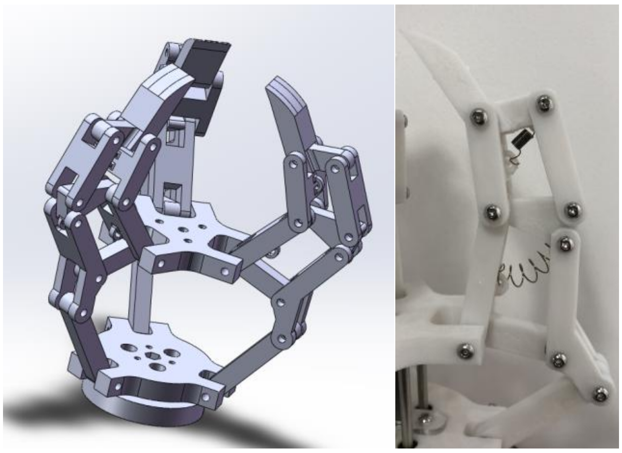

Figure 1: Adaptive mechanical jaws

2.1.2. Lifting mechanism

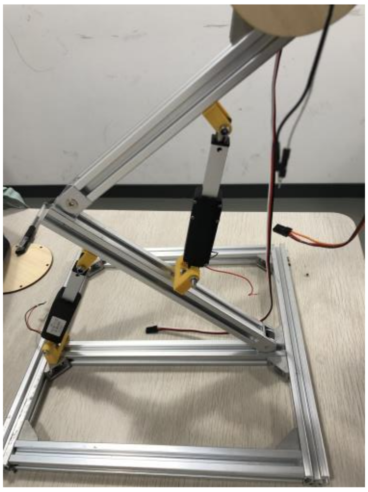

Figure 2: Lifting and lowering mechanism

In order to adapt to different heights, the use of dual actuator drive, the use of two electric actuators composed of "Z" structure, to achieve the lifting effect of the device, can be for different heights of the fruit to grasp, as shown in Figure 2.

2.1.3. Double-degree-of-freedom structure

Figure 3: Double-degree-of-freedom structure

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This part of the structure is mainly for the mechanical claw to provide a "wrist" function, for the mechanical claw to achieve the power of rotation in space. Its ability to grasp from different directions and to achieve the "twist" effect and FPC material is soft, can be arbitrarily bent, folded, wound, can move in three dimensions, and stretch without breaking, as shown in Figure 3.

2.2. Skill application

2.2.1. Embedded systems

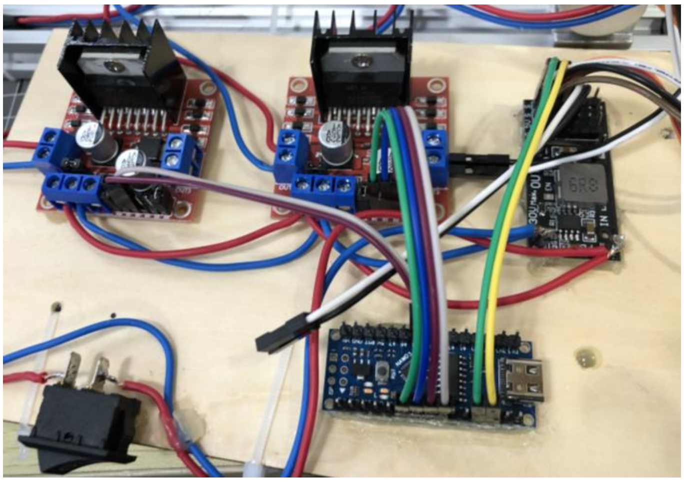

Figure 4: Arduino Nanosystem

The embedded part is centered on the Nano board. The controller receives the control commands sent by the Bluetooth module, processes the control signals, and then controls the motor driver, servo, and other devices to work, realizing the action of grasping, turning, and lifting of the device. Two motor drivers are used in the device to control two-point actuators and a screw motor, and two servos are used to provide rotation of the mechanical jaws, as shown in Figure 4.

2.2.2. Solidworks design and 3D printing

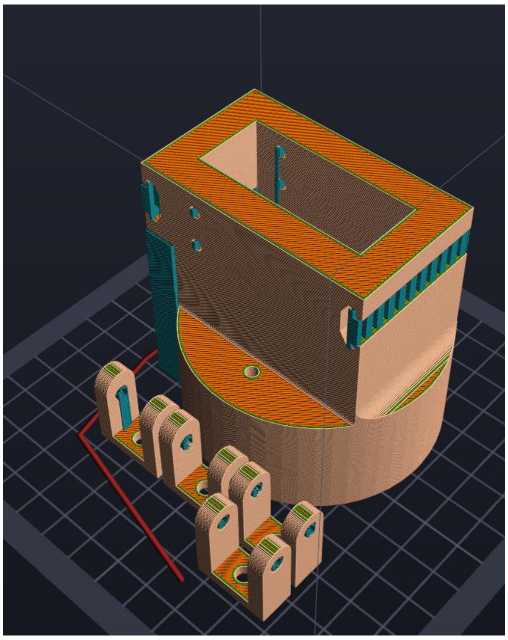

Figure 5: CAD drawing and laser cutting

In this project, the main material used for the equipment is PLA resin and 20*20 aluminum profile. The processing method is mainly 3D printing, so we need to use the software to design the 3D model first, complete the parts, assembly, and other parts, and then export the model format to STL format, which can be recognized by the slicing software, and then use the printer to process, as shown in Figure

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5.

2.2.3. Arduino programming

Figure 6: Arduino programming

The programming software uses Arduino IDE. The programming language is C++, with a large number of open-source library functions, which can quickly implement the developer's functions without having to spend all the effort for the underlying development. The open-source blinker platform is used in this device to enable wireless Bluetooth control, and the program uses a modular structure that is easy to understand, as shown in Figure 6.

3. Conclusion

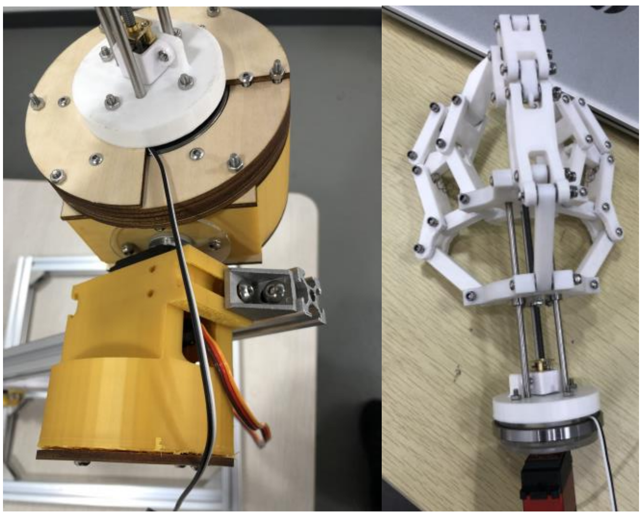

Figure 7: Finished picture of the real thing

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The following skills are mainly used in this project:

- Embedded systems control and C programming.
- Knowledge of integrated circuits.
- Mechanical design and mechanical principles
- 3D printing.
- Solidworks 3D design.
- Serial communication

The target users of this equipment are small-scale growers who are unable to afford seasonal workers due to increased labor costs, as shown in Figure 7. Although this equipment was expensive at the time they purchased it, it is still a good investment considering that it is easy to maintain and costs much less in the long run. And the equipment has the function of self-adaptation, compared with other mechanical claws, can effectively prevent the fruit from being damaged by mechanical structures, reduce losses, and can be used for large-scale promotion.

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