Virtual Simulation of Fruit Picking Robot Based on Unity3D

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Abstract. With the development of the fruit farming industry, there have been breakthroughs in both scale and harvesting requirements, and the resulting problem is that the demand of picking robot is more and more high, the function, cost and quality of the harvest and picking efficiency compared with the traditional manual operation mode with strong competitiveness for market, that is to say, in terms of cost cheaper, picking at a faster rate, and can avoid damage on the fruit in the process of picking. Therefore, in terms of mechanical structure design, the transmission accuracy and efficiency of the picking robot should be improved. At the same time, the structural design of the picking robot should simplify the structure as much as possible, reduce the manufacturing cost, and ensure the feasibility of the picking robot’s functions. Picking robot combined with automatic walking system, automatic detection system and control system-centered intelligent system, can achieve accurate and efficient work in various conditions. Realize picking robot toward automation, intelligence, scientific development. The design of this topic is mainly aimed at the development of the picking robot and the use of analysis, determine the feasibility of the picking robot design and virtual simulation.

1. Introduction
In Occident, the scale of fruit cultivation and fruit collection mode have reached a high degree, agricultural mechanization degree is very high. Due to the advanced information technology in Occident, there are a large number of fruit growers who buy efficient agricultural collection equipment, hence there are many kinds of fruit picker equipment in Occident with a high level. The fruit planting patterns of the United States and China are different [1-3]. The United States has a large scale, relatively concentrated fruit planting and strong capacity to produce modern agricultural equipment. American fruit picking machinery is not only complete, but also has a high degree of automation. China's agricultural equipment manufacturing enterprises should catch up with the America in this aspect of the pace of development [4].

Developed countries compared with our country have some advantages. At present, in fruit picking robot ways, the Virgo 1 intelligent picking robots which produced by the Root AI company is mainly used for tomato picking, this robot can not only high precision positioning of the location of the fruit, but also can real-time detection of the maturity of the fruit [5-7]. This series of intelligent picking robots can realize regular fruit picking with high accuracy and efficiency. At the same time, their “machine’s fingers” can pick the fruit with appropriate strength by themselves when picking, so the fruit will not be damaged. Virgo 1 intelligent picking robot provides automatic detection of fruit eligibility, combines multiple performance indicators to make picking of eligible or ripe fruit the first time, and is easy to maintain and replace wearing parts [8-10].

Therefore, the innovation and the development of the agricultural equipment also motivates developers in the future research and development to produce the high quality, high automation of...
agricultural machinery, let farmers are able to use these equipment to engage in agricultural production activities, to improve the effect of agricultural product quality, reduce production costs, this is the key of the agricultural economy development in the future [11]. The slow development of agricultural economy slows down the increase of farmers’ income, hence China's agricultural production needs to develop towards scale and high efficiency. The design and production of scientific and advanced agricultural machinery can make agricultural economy develop better. The design and manufacture of fruit picking robot can reduce the manufacturing cost of the robot, simplify its internal structure and increase its practicability, which are the needs of the development of modern fruit planting industry. Making affordable, well-used fruit pickers is the goal of modern fruit farming.

2. Overall Scheme Design

The action part of the fruit picking robot and manipulator designed in this paper includes the rotation of the base, the swing of the big arm and the small arm as well as the rotation of the hands, so as to realize the fruit clipping by the hands. Manipulator claw through servo motor drive, gear transmission, so that the opening and closing Angle of the claw can be controlled by the operator, manipulator claw clamping diameter range of 60mm 80mm, need to have the torque to maintain, operating speed control characteristics.

The fruit picking robot can operate in a single mode or a combination mode. In the former, the rotary table is rotated and positioned first, then the pitching operation is carried out by the upper arm and the lower arm respectively, then the wrist is rotated, and finally the hand is responsible for picking fruit. It can also control the movement of both the joints and the axis of motion so that they can run simultaneously. Designers can choose the most efficient way to operate the control equipment according to their own needs and the control devices they use. The overall mechanism of the equipment is composed of chassis, base, large arm, small arm and execution claw, etc. Because it has five degrees of freedom, five stepping motors should be used to control the manipulator.

3. Brief Description of Main Organization

Picking execution system is the core part of the picking robot, which is the executive mechanism to realize automation of fruit picking. Picking execution system uses five degrees of freedom mechanical arm structure, the main structure consists of foundation, pedestal, arm, forearm and hand, and between each joint rotation or oscillating motion can be realized. Therefore, its degrees of freedom of movement and flexibility, it can ensure that picking execution system in the process of picking movement request. Due to the picking robots working mode is mobile work. Therefore, it is necessary to add a walking device for supporting. The walking system is powered by a battery and driven by a motor. The device adopts a precursor structure, which is characterized by flexible steering and reliable movement. Meanwhile, retaining the back-end space for installing the fruit storage box and the mechanical arm structure. The robot’s recognition system can act as the robot’s “eyes” to identify the location of the fruit. The system through the different color and the different feedback signal, to discern the fruit's maturity automatically. The principle is to identify the RGB color value outside the target object to determine its color. In the design of picking robot identification system, choosing the photosensitive resistance and RGB-LED as the sensor, so that the sensor precision is good, which can reach 0.01 V. Although such a sensor has good accuracy, it may not be ideal to a certain extent in using because it is greatly affected by the external environment.

4. Main Component Structure

The structure of the execution claw is shown in figure 1. In the structure of the fruit picking robot, the execution claw is similar to the wrist part in the structure of human body, and its function is to move and rotate objects. The design requirements are: ensure the execution claw has enough grip, and ensure it do not damage the objecting when moving the object. The acting principle of the execution claw is driven by the servo motor to output speed and torque. The transmission is responsible for adjusting the speed. After the gears transmission, the torque and speed are transferred to the shaft sleeve. The
mechanical claw can be mounted and removed on the shaft sleeve, so that the mechanical claw can clip the object.

Figure 1. Execute the claw structure diagram.

The structure of the big arm is shown in figure 2. The important parts of the arm are driving gears and supporting bearings. The structure should meet the requirements of bending and torsion. The material of the shaft (1) is No.45 steel, hardening and tempering HBS217-255. Its mechanical properties can be obtained by looking up the table,

\[ \sigma_b = 650 \text{MPa}, \quad \sigma_y = \text{MPa}, \quad \sigma_{s-1} = \text{MPa}, \quad T_{s-1} = \text{MPa} \]

Allowable fatigue stress \( [\sigma_{s-1}] = 190 \text{MPa} \).

Figure 2. Arm structure drawing.

(2) Calculation of axial forces:
The radial and circumferential forces on the gear are:

\[ F_r = \frac{2000 T}{d} = \frac{2000 \times 1}{18} = 111.11 \text{N} \]

\[ F_c = F_r \tan \alpha = 111.11 \times \tan 20^\circ = 40.44 \text{N} \]

\[ N_1 = N_2 = 36.75 \text{N} \]

The resistance torque:

\[ M_1 = M_2 = 0.5 \text{N} \cdot \text{m} \]

Gravity \( N_3 = 20 \text{N} \cdot \text{m} \); Active torque \( M_0 = 1 \text{N} \cdot \text{m} \).
Calculate the force acting on the horizontal plane of the axis:

\[ R_{Ax} = \frac{111.11 \times 13}{26.8} = 53.90N \]

\[ R_{Bx} = \frac{111.11 \times 13.8}{26.8} = 57.21N \]

The mechanical claw is shown in figure 3. The connection part between the executive claw and the flange plate is the connection flange, and the motor drive provides power for the mechanical claw. After the power is provided to the input shaft, the input shaft then transfers the power to the rack. At this time, the rack can move forward or backward, and the power is transferred to the gear and drive its rotation, and then the gear will transfer the power to the connecting rod and drive its swing, and finally the connecting rod mechanism will transfer the power to the clamping plate, so that the clamping plate can achieve the action of clamping object.

5. The Experimental Modeling
Create model animation. That is assign actions to the structure of each part of the model in 3Ds Max. The specific operation steps are as follows: first, all the objects in the model are created a parent-child relationship and linked them together. After the linking, the automatic key frame is opened, and the action of the manipulator is adjusted by creating a key frame for each object. The claw part needs to use virtual object, that is, create a virtual object to link to the apple, then create a virtual object to link to the apple tree, when the claw moves to the position of the apple, perform the plucking action, link the virtual object to the claw; When moving to the storage box to perform the action of putting down the apple, the animation of the hand claw is to release first, then create a virtual object to link to the apple, and finally create a link to the virtual object to link to the box or the world, then release the claw and put down the apple. The final effect is shown in the following figure 4, viewing the animation from two different perspectives.

The results are shown in Unity 3D virtual simulation in figure 5 which shows the Game interface in the process of running state.

Figure 3. Arm structure drawing.

Figure 4. Effect diagram.
Complete the whole fruit picking virtual simulation animation time is about 15 seconds, final effect is presented: the car moving to picking point position, but because in Unity 3D can't reflect the role of sensors, hence it can only be done by setting the coordinates to reach the picking point, after arriving at the location, through the rotation of each joint mechanical arm and hand claw rotation, picked to apple, and then through the rotation of the base, the whole mechanical arm switch to rear storage tank, storage tank open at the same time, robots will return to the initial position after apple in the box, storage box shut down at the same time.

In the process of realization of the simulation, met many problems, such as the model error, the scene of the put, the problem such as rendering, but one of the biggest difficulties is to import the model error, which is also directly contributing to the follow-up have to change in the scripting programming logic, and the writing the program is one of the difficulties, but ultimately it achieve the basic process of picking fruit by picking robot.

6. Conclusions
Fruit picking robot is a hot spot in the development of agricultural high-tech equipment. It is also one of the directions of the continuous development of highly informatization machinery industry. Therefore, it has good practical significance to analyze and explore it. With the advent of high-technology society, fruit picking robots will be increasingly valued by fruit growers. At present, this kind of equipment has begun to replace the traditional manual operation, and has many advantages. It can work 24 hours a day, and can work continuously during the ripening period of fruit. It does not require any emolument so that the cost incurred by the activity is reduced. High-quality fruit picking robots can not only improve the speed of fruit picking, but also effectively guarantee the quality of fruit, which has a good promotion effect on the improvement of economic benefits of fruit growers.

In this graduation project, I have learned the basic usage of Unity 3D software. Although I have not fully grasped all the functions of the software, I have also learned that Unity 3D is not only a game engine, which can be used for game development, but also applicable to other industries, which can provide convenience for people and meet the needs of the public.

Acknowledgments
This project was supported by the General Program of Chongqing Natural Science Foundation (Grant No. cstc2019jcyj-msxmX0812), Science and Technology Research Program of Chongqing Municipal Education Commission (Grant No. KJQN201901308, KJQN201901313), Chongqing University of Arts and science talent introduction project (Grant No. R2018SJ1D17, R2019FJ005) , and Yongchuan Natural Science Foundation Project (Grant No. Ycstc, 2019nb0802).

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