A Bionic Hand Pineapple Picking Rod

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Abstract—*Pineapples are only hand-picked hardly, time-consuming and strenuous apparently, for the special picking way. Pineapple harvesting cost accounts for a high proportion of the entire process, which leads to inefficiency and low profit. This project designs a low-cost picking tool that can protect pineapple farmers. The mechanical structure proposed is a combination of a pull rope and a planar four-bar mechanism. When the rope is pulled, the gears small and large are driven accordingly, which can enlarge bite force of cutter working through angle reducing user's pressure. In addition, it equipped with export pipelines and trucks, which solves the difficulty farmers has to carry heavy fruit baskets in low-growing and dense bushes. It greatly improves pineapple picking efficiency and is of great significance alleviating the farmer labour intensity, which promotes development of the pineapple picking industry.*

Keywords—*Bionic Hand, Pineapple Picking, Planar Four-bar Mechanism*

I. INTRODUCTION

Pineapple is very popular because of rich nutrition, excellent quality, and attractive aroma, and the demand for pineapple is increasing constantly. However, the pineapple harvesting is heavy work always requiring a lot of labour. Most of the current fruit picking ways in China is mainly hand-picking. The picking work is complex and highly seasonal, while farmers need certain training. The problem that the loss of experienced seasonal labour in large amount makes fruits rotten without picking becomes increasingly prominent[1]. If manual picking is still used, it is not only inefficient and labour-intensive, but also easily damages fruit. When the labour is not enough, it will cause the bigger economic losses.

At present, only hand harvests can be performed for the special growing environment and fruit of pineapple, while a full-automatic picking method without manual work has not yet been achieved. Therefore, how to reduce the burden on pineapple pickers, make people away from troublesome spikes, and improve the efficiency of picking becomes the focus of the research[2]. Pineapple leaves are sharp and hard with serrated edges. Pineapple farmers need to wear protective clothing and masks when picking to avoid being hurt. During the picking process, the pineapple farmer needs to cut off the pineapple from the plant with a knife and store it in a basket on the back. Therefore, the pineapple farmers must carry heavy baskets and walk through the orchard, while the physical exertion is very large. The manual labour for picking pineapples is extremely intensive, but inefficient and time-consuming. Harvesting costs account for about 40% of the pineapple industry[1-3]. Today, with agricultural production tending to be mechanized, it is the trend that the man-machine interactive mode gradually replaces the absolutely manual working mode in the process of pineapple picking.

Considering the economic value of pineapple leaves and the structural features of pineapples, the project designs an auxiliary device practically called bionic hand pineapple picking rod, helping pineapple farmers to pick pineapples more easily and quickly.

II. STRUCTURE DESIGN

A. Overall Pattern

The main structure shown in Fig.1 is a mechanical picking hand[4-5], which is mounted on the front of a 70cm straight rod

forming as a whole frame. This mechanism c be held by hand, or fixed on a cargo trolley where straight rod needs be fixed on the cargo trolley by moving parts. The manipulator on the transport vehicle is about 0.4m~0.6m high above the ground with adjustable height. This method guarantees that the pole can get support, and the space moving left and right is not restricted.

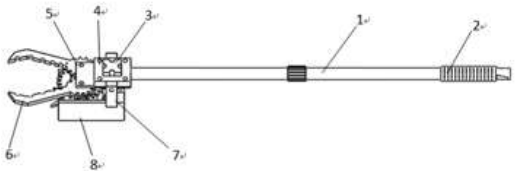

Fig.1 Graphic model of the mechanism

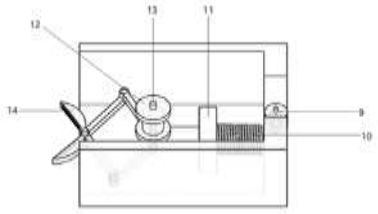

Fig.2 Partial enlarged view of the device

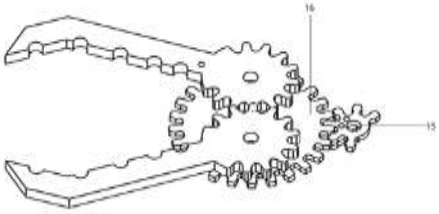

Fig.3 Partial enlarged view of the gear
1-Straight rod; 2-Friction pad; 3-Steering engine;
4-Steering engine platform;
5-Clamping front connecting plate;
6-Tongs for clamping device;
7-Upper and lower connecters;
8-Scissors-carrying box; 9-Pulley block;
10-Spring; 11-Plane four-bar mechanism;
12-Pulley; 13-Vertical connecting rod;
14-Scissors; 15-Steering engine driven gear;
16-Large transmission gear; 17-Base plate

The core of the picking device is a bionic hand in the front of the pole, which is divided into two parts. The upper part is a clamping protection mechanism, while the lower is a planar four-bar mechanism to cut off the pineapple. The main transmission structure is shown in Fig.2 and 3[6-9].

B. Lower Level Device

One end of the traction rope tied to the picking hand is passed over the pulley 12, while the other end is connected to the flow-type pressing device near the hand by a steel wire rope. The pressing of this device drives the movement of the traction rope, to control the diamond-shaped scissors to cut off the pineapple stems and leaves. The movement of the diamond-shaped scissors is mainly based on a planar four-bar mechanism, composed of four rigid members with a lower pair mechanism. The main planar kinematic pair at the end is controlled to drive the entire planar four-bar mechanism by the limit position of the bottom plate shown in Fig.2. The planar four-bar mechanism is the main component connecting the front diamond knife and the traction rope, which can enlarge bite force of cutter working through angle, so that the scissors can cut off the stems and leaves at maximum angle reducing user's pressure. A return spring is added between the scissors-carrying box 8 and the plane four-bar mechanism 11. With the reset characteristic of the spring, the front-end scissors can bite when press, while open when release. The device can harvest pineapple from the plant constantly improving the efficiency.

C. Upper Clamping Device

A ring clamping tongs 6 is similar to an open hand of human being on the top of the picking hand. This mechanism has two functions. One is to move the sharp leaves near the pineapple fruit far away to protect the pickers, and also avoid affecting picking process. The other is to prevent the picked pineapple from damage when it falls without any supports. The clamping mechanism can restrict the pineapple to a certain range, forming two supporting points with closed knife blade at the lower end to ensure that the pineapple will not fall. Then the fruit will be quickly transported to the truck nearby or stacking place.

Gear transmission is employed in the system shown in Fig.3 as a widely used transmission form. The steering engine 3 drives the small gear 15 to rotate within a certain range, thereby drives the large gear 16 rotating. There is a small hole in the clamping tongs 6, where a rod passes

through and is fixed to the large gear 16 to make the large gear 16 and the clamping tongs 6 into a whole transmission mechanism. The open and close of clamping tongs are controlled by the steering engine.

D. Pulley Block

The pulley block is composed of three fixed pulleys for the purpose of saving 1/4 force. The pulley 12 and the pulley block 9 composed of two small pulleys are passed by the traction rope, which enables the operation to complete with less force.

III. DESIGN AND CALCULATIONS

E. Overall Design

There are many types of gear transmissions with different uses. However, with the requirements of transmit motion and power, both problems of stable transmission and sufficient bearing capacity must be solved. This device selects low-speed large gears and high-speed little gears to reduce the size and weight of the machine body, reduce noise and vibration, and improve the stability and bearing capacity. The gear transmission ratio is

$$i = n_1 / n_2 = D_2 / D_1 \quad (1)$$

An example is shown in Fig.4.

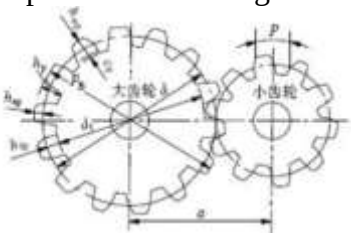

Fig.4 Practical example of gear

Fig.5 Steering engine

F. Determination of Basic Parameters

The bionic hand pineapple picking device uses a pulley block composed of a fixed pulley and two movable pulleys, and the steering engine as the power input device. The steering engine mainly consists of an outer skin, a circuit board, a coreless motor, gears and position sensors. For safety and clear observation of the experimental phenomena, the reacting rotational speed of steering engine is set to 0.12~0.13 seconds per 60 degree, and the working torque is 1.6kG/cm.

IV. TEST RESULTS

The effect of this device is shown in Fig.6 that the cooperation of the knife blade and the clamping device can easily cut off and firmly hold the pineapple. It is confirmed that the mechanized function of pineapple picking is realized assisting pineapple pickers in charge of operations.

Fig.6 Experimental result

V. CONCLUSIONS

The equipment designed with light quality is easy to operate manually and has high safety. It especially reduces the burden on the pickers which greatly improves efficiency, and reduces damage to fruits, plants and pickers in working process. Considering artificial picking is the main way of fruit picking in current domestic environment, this product has an excellent application prospect which will increase the profit of fruit cultivation and promote the development of the pineapple picking industry.

ACKNOWLEDGMENT

This research was partly supported by the Shanghai university student innovation and entrepreneurship project (Grant No. 201910856007).

REFERENCES

[1] Xiuying Tang，Tiezhong Zhang. Robotics for Fruit and Vegetable Harvesting: Review[J]. Robot, 2005(01).

[2] Ling Tong, Yuhong Zheng. Development Trend of Agricultural Machinery in the 21st Century—Application of Agricultural Robots[J]. Agricultural Machinery and Food Machinery, 1996(6):2-4.
[3] Jieli Duan, Huazhong Lu, Weizu Wang. Liang Wang, Lei Zhao. Present Situation and Development of the Fruit Harvesting Machinery[J]. Guangdong Agricultural Science, 2012(16).
[4] Jian Zhang. Design of Mango Picking Robot[J]. Practical Forestry Technology, 2015(5).
[5] Xuxing Jin. The Manipulator Innovation Design for Picking Fruit[J]. Institute of Agricultural Mechanization, 2009, 31(7).
[6] Heng Sun, Zuomo Chen, Wenjie Ge. Theory of Machines and Mechanisms[M], BeiJing: China Times Economic Press, 2008.03.
[7] Qinghua Liang, Huijun Zou, Jinqiu Mo. Interesting Mechanism[M], BeiJing: Machinery Industry Press, 2013.05.
[8] Y Edan, E Gaines. Systems Engineering of Agricultural Robot Design[J]. IEEE Transactions on Systems, Man, and Cybernetics, 1994, 24(8):1259-1265.
[9] RC Harrell, PD Adsit, RD Munilla, et al. Robotic Picking of Citrus[J]. Robotica, 1990, 8(4). 269-278.