Single-traction Mountain picking aid system

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Abstract. In order to improve the efficiency of orchard picking and reduce the labor intensity of picking, a "single-person, high-efficiency" picking operation system based on manual picking is designed. The system can realize the picking, automatic conveying and sorting according to the weight under the manual assisted identification of Apple, and design the various functional units in the device to complete the spatial layout and size design.

1. Introduction
China is a big apple producing country, and its output accounts for more than 65% of the world's total apple production [1]. Fruit picking operation is the most important part of the whole agricultural production. The fruit picking time is short, the workload is large, and mechanization is needed to reduce the harvesting cost and improve the production efficiency. At present, China has large-scale vehicle platforms and robots for picking. However, China has a vast territory and diverse terrain. It is densely planted in multiple terraces in mountainous and hilly areas, and it is difficult to carry out large mechanized picking operations. This paper designs a single-person traction mountain picking aid system to provide a solution for the research of picking equipment for mountain terraces.

2. Machine mechanism and working principle

2.1. Structural composition
The single-traction mountain picking auxiliary system mainly includes three-stage picking and telescopic arms, flexible fruit transfer pipelines, fruit grading system and four parts of the vehicle body. The schematic diagram of the vehicle body equipment is shown in Fig. 1. The fruit grading system mainly includes a three-open weight screening device as shown in Fig. 2, and the third-stage picking telescopic arm is shown in Fig. 3.
2.2. Power and automatic control system

The single-traction mountain picking auxiliary system power system described in this paper includes 24v10Ah lithium battery, stepper motor, and other control switches, lines, membrane pressure sensors, and Arduino development boards. The three-stage picking telescopic arm and the fruit grading system are electrically driven, and the steering gear and the stepping motor are separately used to provide power. The circuit and control circuit of each part constitute the control system and power system of the picking aid.

The expansion and contraction of the three-stage telescopic arm are manually controlled by the amount of elongation. The control of the stepping motor can be used to control the rotation of the two sets of through-screw stepper motors to achieve the elongation and shortening of the entire device. When the apple falls to the fruit grading device, the film pressure sensor attached to the above will detect the weight of the apple, and the rudder is controlled by the Arduino program to drive the screening touch panel to complete the three-level screening.
2.3. Working principle of the single traction mountain picking auxiliary system

The single-traction mountain picking aid system described in this paper is based on the picking operation of the fruit farmers and the action process of the fruit farmers to classify the apples according to the weight, and the whole design is carried out from picking, transshipment, and sorting. The system implements the above three kinds of action flow, picking the apple by picking the telescopic arm, decelerating and reducing the falling process of the apple through the two-stage bundle-shaped elastic bell-type speed reduction mechanism and the flexible pipe, and performing the apple on the weight screening device. Grading. For fruit picking at different heights, the system solves this problem by telescopic picking arms. The telescopic arm passes through two sets of two sets of lead screw stepping motors, which can control the extension and shortening of the telescopic arm between 700 and 1620 mm (Fig. 4 is the longest extension state of the telescopic arm, and Fig. 5 is the shortest extension state of the telescopic arm), while the height of rural adults is between 1500 and 1800 mm, in this way, apples can be picked up within 2100~3420mm from the ground. The cutting edge of the picking head is "V" type, which can be easily positioned to the handle of the apple, and then the "V" type cutting edge can effectively prevent the fruit stem from being detached. The two-stage bundle-shaped elastic bell-type speed reduction mechanism can effectively decelerate the apple through the combination of the curved nylon slats and the rubber band. According to tests, the average speed of the apple can be reduced to 0.5m in the transmission pipeline after deceleration. Below s, the speed of the apple outlet is not more than 0.2m/s.

The three-open weight screening device uses Arduino as the control core. When the apple falls on the screening touch panel, the film strain gauge on the touch panel is screened for data acquisition, then the Arduino is used for strain data analysis, and finally, the steering gear is driven to filter the touch. The board is open. The processing accuracy of the film type strain gauge is within 10 g, which is in accordance with the conditions of fruit sorting. The entire screening process takes about 2~3s and can process 20~30 fruits per minute. As shown in Figure 2, a three-open weight screening device.

The classification box is made of foam box, which can effectively reduce the impact damage of the fruit. The box is divided into three parts, which can accommodate three different weights of apples. Actually, the damage rate of the fruit after the three-open weight screening device was screened by the
two-stage bundle-shaped elastic bell-type speed reduction mechanism and the flexible fruit transfer pipeline was not more than 3%.

2.4. Main technical indicators
For the domestic mountain terraced planting varieties and orchard fruit trees planting plant spacing, tree height, row spacing, crown width, etc. [3]. The actual single-person traction mountain picking auxiliary equipment design parameters determined by actual measurement and comparison are shown in Table 1.

| Parameter name                                      | Value                         |
|-----------------------------------------------------|-------------------------------|
| Telescopic arm fully contracted                      | 700mm                         |
| Telescopic arm fully extended                        | 1620mm                        |
| Body size (length × width × height)                  | 800mm×600mm×400mm             |
| Telescopic boom picking height                       | 2100~3420mm                   |
| Average transshipment speed within the apple pipeline| <0.5m/s                       |
| Apple out of the pipeline speed                      | <0.2m/s                       |
| Three-open weight screening device takes time        | 2~3s                          |
| Apples collide with each other in the fruit box      | <0.3m/s                       |
| Number of fruits harvested per minute in continuous operation | 20–30个                      |

3. Key components and parts assembly design

3.1. Bundle elastic bell type speed reduction mechanism
The material of the bundle-shaped elastic bell-type speed reduction mechanism is nylon plate and rubber band. The toughness of the nylon plate is good [2], which can produce large bending, and the plate itself is slightly rough to provide a certain resistance. The role of the rubber band is to bend the nylon plate to create enough resistance to the apple as it passes by. Each piece is 20mm wide, 500mm long and six pieces in a group.

Fig. 6 Bundle elastic bell-type speed reduction mechanism (set)
1. Rubber band; 2. Nylon plate.

3.2. First stage tube fixation
The basic structure of the picking and fixing device on the telescopic picking arm is the same as that of the first tube. Therefore, the first stage tube fixing is taken as an example. The material for the primary segment is ABS (acrylonitrile-butadiene-styrene plastic). The inner diameter of the part is 120 mm, and 18 threaded holes are arranged in the inner hole, and the axial angle of the hole is 20 ± 0.5°. These threaded holes are for the convenience of mounting a bundle-shaped elastic bell-type speed reduction mechanism.
3.3. Telescopic arm inner tube assembly design

There are 18 inner holes of the telescopic arm, and the bundle-shaped elastic bell-type speed reduction mechanism has six pieces in each group, which can be installed in two groups, and the other group is a non-deceleration tube set, which is fixed at both ends. The assembly scheme is shown in Figure 8.

4. Conclusion

The single-person traction mountain picking auxiliary system discussed in this paper comprehensively considers the topographical features of terraces in the hilly terrain, the growth of apple trees and the distribution of fruits, and solves the problem that the apple trees are difficult to pick during the picking process. The problem of secondary classification and sorting after picking improves the picking efficiency of farmers and reduces the labor intensity of farmers' picking. Due to the problem of sorting and grading after the end of apple picking in actual production, the villagers have a long picking cycle. The three-open weight screening device discussed in this paper uses the Arduino as the main controller to process the signal of the thin film strain gauge. The time for fruit sorting is reduced to 2~3s, which greatly improves production efficiency and shortens the picking cycle. In the process of fruit transport, the bundle-shaped elastic bell-type speed reduction mechanism has the characteristics of an obvious deceleration effect and small damage during transportation. This design can also be applied to the picking of other fruits with a certain degree of modification.

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