Design of Apple Picking Machine Based on Motion Controller

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Abstract. Aiming at the existing problems in the apple industry, a kind of automatic apple picking machine based on the motion controller is designed. The structure design and software design are introduced. Focus on the analysis of the picking mechanism, which can not only guarantee the efficiency, but also guarantee the quality of the apple after picking. The apple picking machine has the advantages of simple structure, convenient use. It provides a new idea for apple picking.
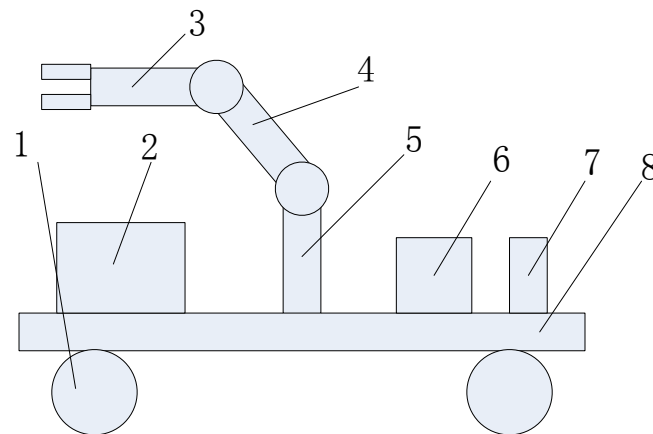
Keywords: Apple picking machine; Control system; Motion controller

Introduction

China is a large agricultural country, the fruit industry is one of the important industries of agriculture [1]. In recent years, the continuous development of fruit industry in our country has made considerable progress, the scale and production of industry have been greatly improved. Among them, the most obvious output growth is apple. Apple is native to Europe, the introduction of China was in nineteenth Century, the earliest place to start planting is Shandong. After years of development, China has become the world's largest apple produce country [2]. The apple cultivates in most areas of China, according to statistics from the Ministry of agriculture shows that up to 2008, apple cultivation area in China has reached 1990000 hm2, and the yield reached 29850000 t, which accounts for the proportion of 1/5 among all the fruit [3]. Apple processing technology is improved, so the market prospect of apple is getting better and better. Output of apple in China is growing year by year, but because of the apple tree is high, apple picking has become a difficult problem to fruit growers. At present in our country apple picking most use the traditional picking way that by hand, this way is relatively backward, it has the disadvantages of high labor cost, high labor intensity and low labor efficiency, at the same time personnel safety is difficult to guarantee. This traditional picking way seriously restricts the development of apple industry. In order to improve this situation, some scholars begin to study the apple picking robot. The present study on picking robot most concentrates in visual system and obstacle avoidance [4-5]. Study on mechanical structure and control system of the picking robot is relatively less [6]. In this paper, the apple picking machine is designed based on the motion controller, in order to provide a new ideas for development of apple picking machine.

Packaging machine system design

Overall design. As shown in Figure 1, apple picking machine is mainly composed of two parts, which are respectively the mechanical part and control part. The mechanical part is mainly composed of end picking mechanism, picking machine arms (the big arm and the small arm) and moving mechanism. The end picking mechanism is responsible for apple, it will pick apple and put the apple into the specified storage box; The picking machine arms are driven by two stepper motors, the motor on big arm can adjust the height of the end picking mechanism, motor on small arm can adjust the end picking machine structure position, through the cooperation of the two arms, end picking mechanism will move to the specified position of picking; picking machine moving mechanism is responsible for the movement of picking machine. Control part mainly comprises a motion controller and motor drivers, they are used to control the motion of apple picking machine.

1.Wheels 2. Storage box 3. End picking mechanism 4.Small arm
5.Big arm 6.Driver 7.Motion controller 8.Frame
Figure 1.The diagram of apple picking machine

End picking mechanism design. The ripe apple fruits are usually round, the volume is relatively large, in order to avoid its damage at the picking time, the picking mechanism must be designed reasonably. Through the analysis of the shape of the apple, the apple picking mechanism is designed into two hemisphere shapes, the entire apple can be wrapped after picking. At the same time, separation of apple and fruit should be designed, according to people picking habits, in general there are rotating separation method, drop separation and knife cutting separation method. Rotating separation method is using the torsional force between apple and fruit trees, but this method may also break the fruit trees, and may cause damage to the apple. The drop separation is a method that directly to pull the apple down the trees. But this method will also appear to existing problems in rotating separation method. The knife cutting separation method is using a knife to cut the apple of the fruit trees, the damage of this method to fruit trees and apple are very small, so using this method. Figure 2 is the schematic diagram of picking mechanism.
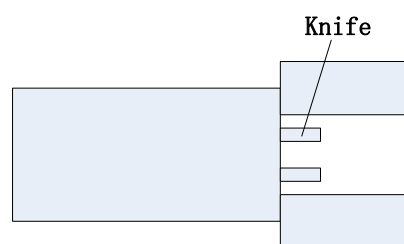

Figure 2.The schematic diagram of picking mechanism

Software design

The software structure design. Motion controller is the core of apple picking machine motion control. But the motion controller cannot run independently, it needs the help of the PC. So the design adopts the principle of upper and lower computer, as shown in Figure 3, it is divided into three modules, respectively they are the program management module, motion control module and parameter module. PC machine as the upper computer will do programming and management, motion controller as the lower computer will control motion of the apple picking machine. Touch screen can communicate with the motion controller, it will do some parameter settings and display, and it can also perform jog program.
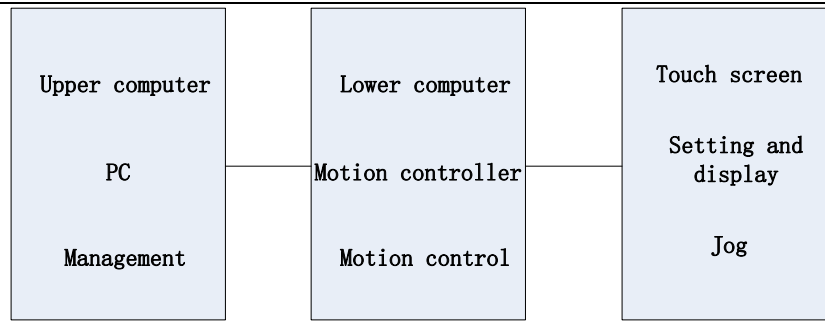
Upper computer	Lower computer	Touch screen
PC	Motion controller	Setting and display
Management	Motion control	Jog

Figure3. The software structure design

I/O design. System receives and sends signals through the I/O interface of the controller, including limiting signal, pressure signal and perform signal etc. The system I/O design is shown in table 1.

Table1. The system I/O design

Input		Output	
IN0	Limit switch 1	OUT0	The picking mechanism open
IN1	Pressure sensor	OUT1	The picking mechanism close
IN2	Limit switch 2	OUT2	Knife open
IN3	Limit switch 3	OUT3	Knife close
IN4	Limit switch 4	OUT4	The indicator light 1
			The indicator light 2
		OUT5	The indicator light 3
		OUT6	
		OUT7	The indicator light 4
		OUT8	The indicator light 5

The program flow design. Apple picking program flow design machine is shown in figure 4. First, the system initializes, and checks the status of the system. After initialization, the picking mechanism is adjusted to the required position through the picking arm. Reaching the designated position, the picking mechanism will pick. There is a pressure sensor in the picking mechanism, when the clamping force comes to the program preset pressure value, picking mechanism will stop clamping, cutting knife closes, so that the separation of apple and fruit trees is done. After cutting, apple will move to the storage tank, then the picking mechanism open, a pick action completes. Then the system prepares the next pick.
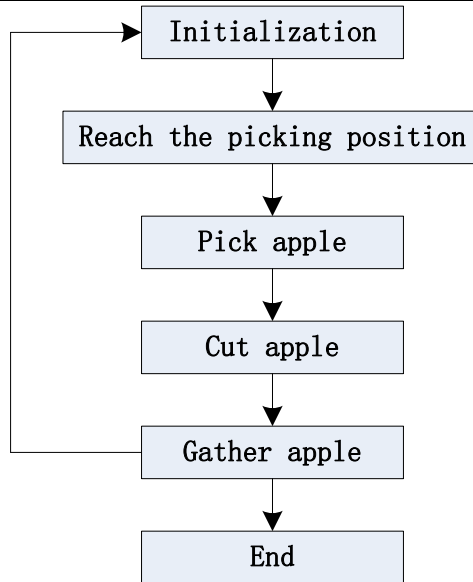
Figure4.The program flow design

Summary

At the present stage, apple picking most also use the manual picking mode in China, the manual picking has the disadvantages of high cost and low efficiency, which seriously restricts the development of apple industry. In this paper, in view of the problems of apple industry existing, a kind of automatic apple picking machine based on motion controller is designed, the structure design and the software design are introduced, the apple picking machine has the advantages of simple structure and convenient use, it provides a new idea for apple picking.

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