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Design of Vegetable Plant Protection Trolley Based on PLC

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Abstract: Firstly, this paper designed a plant protection trolley with a robotic arm, the mechanical arm extends into the gap of vegetables, and the nozzle installed on the robotic arm is used to apply the plant protection solution to the position close to the roots, so that the roots of the vegetables can fully absorb nutrients, increase the efficiency of the plant protection solution applied to the vegetables, and reduce the waste of the plant protection solution. Secondly, the hardware wiring diagram of the electrical control system, the PLC control program and the touch screen control interface of the vegetable plant protection trolley were designed, and the speed and direction of the trolley's walking speed, forward and backward, and the swing of the mechanical arm were controlled through the touch screen.

Keywords: Plant Protection Trolley, Robotic Arm, PLC, Stepper Motor, Touch Screen

1 INTRODUCTION

At present, in Zunyi area of Guizhou Province, the plant protection of characteristic vegetable plants needs to be completed manually, and there are problems such as high operation labor intensity, low operation efficiency, time-consuming and laborious long-term bending to affect health, the existing unmanned aerial vehicle (UAV) is expensive, and the plant protection endurance is limited; the cost of drip irrigation technology is relatively expensive, and a large amount of plant protection liquid is retained in the pipeline at the same time, resulting in the waste of plant protection solution, and the long-term retention of plant protection solution in the pipe will deteriorate, which affects the vegetables.

2 ANALYSIS OF THE WALKING POWER OF THE PLANT PROTECTION TROLLEY

When the trolley walks in the field, it receives the greatest resistance in the case of climbing (considering the same walking road surface and wind speed condition), as shown in Figure 1, but the driving force cannot be greater than the adhesion, otherwise there will be skidding.

The conditions for normal driving are $P_{\psi} \geq P_K \geq G(f\cos\alpha + \sin\alpha)$,

$$P_{\psi} = \frac{G}{L}([(L-l)\cos\alpha + h\sin\alpha]\psi_1 + [l\cos\alpha - h\sin\alpha]\psi_2)$$

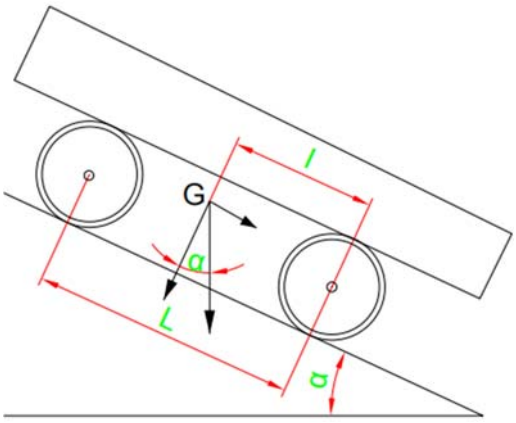

FIGURE.1. SIMPLIFIED FORCE DIAGRAM OF TROLLEY SLOPE

P_{ψ} - Total adhesion; P_K - Total driving force; f - Rolling resistance coefficient; G - Gravity; α - Climbing angle; ψ_1 - Rear wheel adhesion coefficient; ψ_2 - Front wheel adhesion coefficient; h - Distance between the center of gravity of the plant protection trolley and the horizontal plane;L- Distance between the center of the front and rear tires; L-The distance

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between the center of gravity of the plant protection trolley and the rear wheels. According to P_K the driving power of the plant protection trolley, the appropriate stepper motor can be selected [1].

3 Structural Design Of Plant Protection Trolley

In this paper, a plant protection trolley with a robotic arm is designed, including a mobile machine system, a plant protection liquid spraying system, Auxiliary mechanisms such as mechanical arm positioning system and anti-collision, the mechanical arm extends into from the gap of vegetable plants, and the nozzle installed on the mechanical arm is used to apply the plant protection solution to the position close to the root of the vegetable plant, so that the root of the vegetable plant can fully absorb nutrients, increase the efficiency of the plant protection solution applied to the vegetable plant, and reduce the waste of the plant protection solution; The rise and fall of the robotic arm to control the walking speed of the trolley and the speed of the robotic arm movement.

The whole machine mechanism of the plant protection trolley includes a mobile machinery system, a plant protection liquid spraying system, a robotic arm positioning system and an auxiliary mechanism such as anti-collision. The three-dimensional model of the plant protection trolley is shown in Figure 2, and the plant protection trolley is in front of the working process

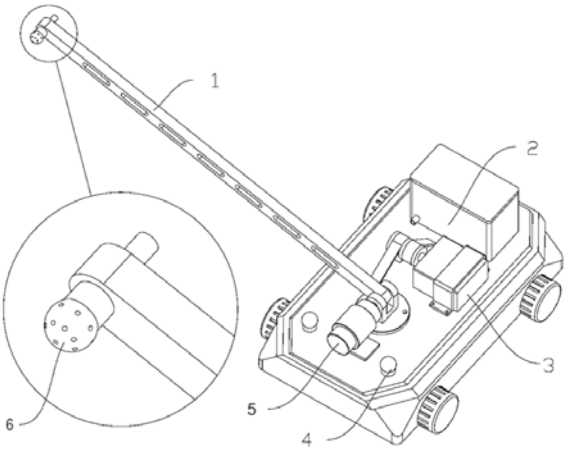

Figure.2. Three-Dimensional Model Of Plant Protection Trolley

1-Robotic Arm, 2-Plant Protection Liquid Box, 3-Stepper Motor, 4-Visual Inspection Equipment, 5-Robotic Arm Rotation Drive Stepper Motor, 6-Sprinkler

Equipped with visual detector 4, the dolly is positioned at the plant position that needs to carry out plant protection by manual, remote control or writing automatic control program; in order to improve the efficiency of spraying plant protection liquid on vegetable plants, the swing of robot arm 2 is controlled by stepper motor 5, and motor and rotating shaft are connected by coupling; in order to be able to continuously and efficiently provide plant protection liquid, the dolly is designed with plant protection liquid box body 2, and the plant protection liquid tank is equipped with hydraulic pump, start pump, will The plant protection liquid is transported to the nozzle, and the trolley is designed with a stepper motor 3, and the driving wheel is controlled by gear, synchronous belt and transmission shaft, so that the trolley moves forward and backward. In order to be able to spray the plant protection liquid more distance, the end of the mechanical arm is provided with an adjustable nozzle 6, and the liquid inlet pipe designed at its end is to convey the plant protection liquid to the nozzle.

The three-dimensional model of the bottom side of the plant protection trolley is shown in Figure 3, plant protection machine

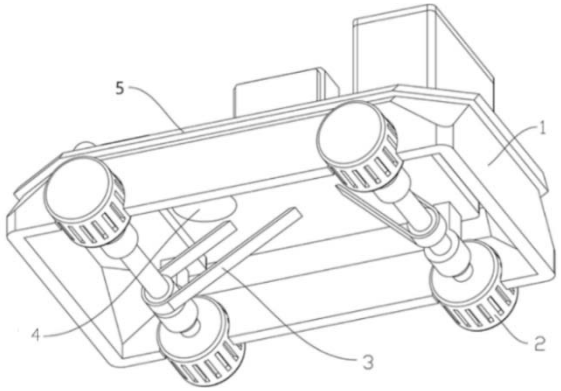

Figure.3. Bottom Side Model Of Plant Protection Trolley

Movable Machine, 2-Drive Wheel, 3-Synchronous Belt, 4-Counterweight Connecting Table, 5-Protective Edge

The working environment of the device is in the dry land or paddy field, the driving wheel 2 is designed with a groove around it, the walking driving force is increased, the trolley walks by the motor drives the synchronous belt 3 and is driven, the motor is designed on the movable table, the soil and water at the bottom will not cause damage to the motor and the driver electrical appliance, and the upper end of the circumferential side of the movable machine 1 is provided with a protective edge 5, which plays the role of anti-collision, The protective edge 5 adopts foam material, so that when the movable machine 1 encounters a puddle, the protective edge 5 is used to make the movable machine 1 float on the water surface, so that the electrical equipment such as motor, controller, and battery will not be burned out because of touching water.

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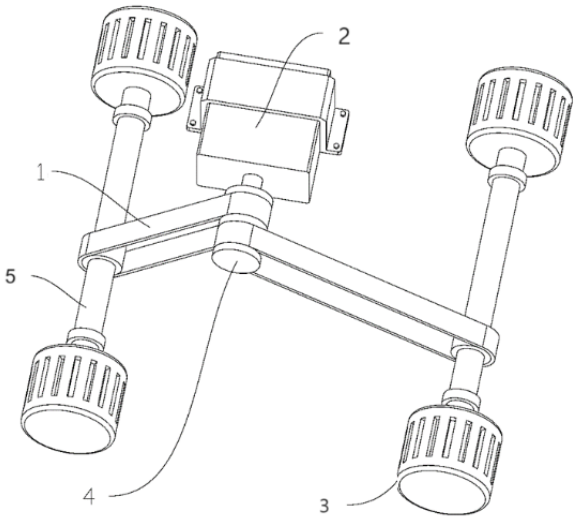

FIGURE.4. DIAGRAM OF TROLLEY DRIVING FORCE TRANSMISSION STRUCTURE

1 - Timing Belt, 2 - Stepper Motor, 3 - Drive Wheel With Grooves, 4 - Gear, 5 - Gear Shaft

The trolley driving force transmission structure diagram is shown in Figure 4, and the stepper motor drives the gear 4 to rotate, and the gear 4 drives the synchronous belt 1 to drive the gear shaft 5 to rotate.

The mechanical arm connection diagram is shown in Figure 5, the swing of the mechanical arm is realized by the program control stepper motor, the motor shaft and the mechanical arm 2 adopt multi-key connection, and the mechanical arm is designed with a plurality of hollow weight reduction grooves, so that the mechanical arm swing is more stable and lightweight, and the counterweight connection table 3 guarantees the stable and safe work of the mechanical arm Through the runner frame at the bottom of the movable machine, the movable machine is easy to move, the mechanical arm is extended from the gap of the vegetable plant by controlling the angle of the mechanical arm, and the plant protection solution is applied to the position close to the root of the vegetable plant by utilizing the nozzle installed on the mechanical arm, so that the root of the vegetable plant can fully absorb nutrients, and the efficiency of the plant protection solution applied to the vegetable plant is increased, so as to reduce the waste of the plant protection solution.

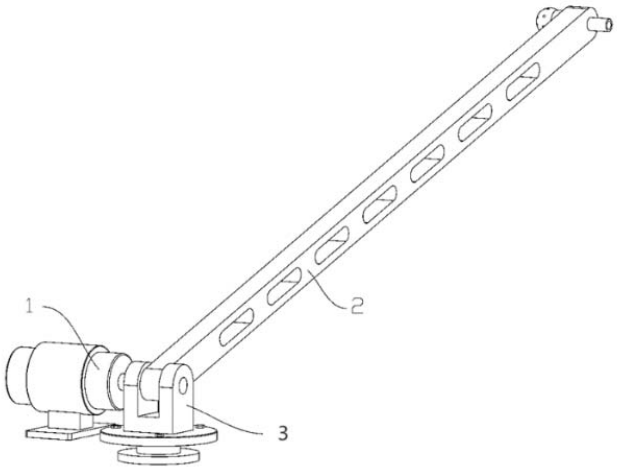

FIGURE 5 CONNECTION DIAGRAM OF THE ROBOTIC ARM

Stepper motor, 2-robotic arm, 3-counterweight connection table

4 DESIGN OF PLANT PROTECTION TROLLEY CONTROL SYSTEM BASED ON PLC

4.1 *HARDWARE WIRING DIAGRAM DESIGN OF PLANT PROTECTION TROLLEY CONTROL SYSTEM*

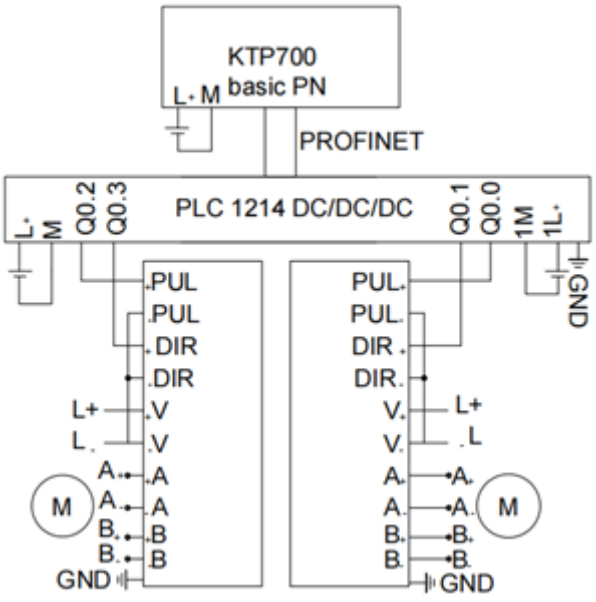

FIG.6. WIRING DIAGRAM OF THE ELECTRICAL SYSTEM OF THE PLANT PROTECTION TROLLEY

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In order to meet the requirements of the precision control of the plant protection trolley walking and the swing of the robotic arm, the walking of the plant protection trolley and the swing of the robotic arm are driven by stepper motors, and the hardware wiring circuit of the control system is shown in Figure 6 [2-3], in which the PLC is selected PLC1214 DC/DC/DC, and the touch screen is KTP700 basic PN.

4.2 Control System Software Design

The speed and direction of the plant protection trolley walking and the swing of the mechanical arm are controlled by touch screen, and the input and output address allocation table is shown in Table 1.

Table 1 I/O Address Allocation Table

class	name	address
Touchscreen input Touchscreen input	Motor 1 is enabled Motor 1 rotates forward	M1.0 M1.1
Touchscreen input	The motor 1 is reversed	M1.2
Touchscreen input	Motor 1 stops	M1.3
Touchscreen input Touchscreen input Touchscreen input	Motor 1 speed setting Motor 2 is enabled Motor 2 rotates forward	MD100 M2.0 M2.1
Touchscreen input	Motor 2 reverses	M2.2
Touchscreen input	Motor 2 stops	M2.3
Touchscreen input	Motor 2 speed setting	MD110
PLC output PLC output PLC output PLC output	Stepper motor 1 pulse Stepper motor 1 direction Stepper motor 2 pulses Stepper motor 2 directions	Q0.0 Q0.1 Q0.2 Q0.3

The main program of plant protection trolley walking and mechanical arm swing speed and direction control is shown in Figure 7 to Figure 9, and the stepper motor control subprogram is shown in Figure 10 to Figure 12, wherein M1.0 and M2.0 are the enable input signal of motor, M1.1 is the forward rotation control input signal of motor 1, M1.2 is the reverse control input signal, M1.3 is the stop control input signal, MD100 is the motor 1 speed setting input terminal, M2.1 is the forward rotation control input signal of motor 2, M2.2 is the reverse control input signal, M2.3 is the stop input signal, and MD110 motor 2 speed setting inputend [4-6].

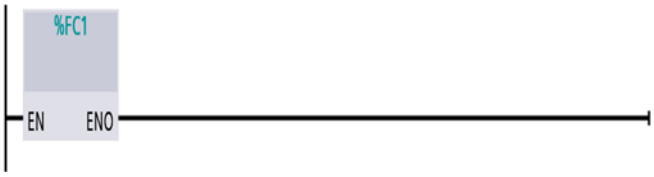

Figure 7 Invoking Stepper Motor Control

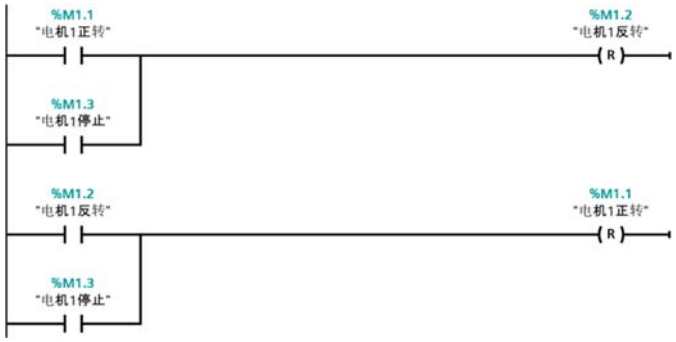

Fig.8. Motor 1 Forward And Reverse Rotation And Stop Control

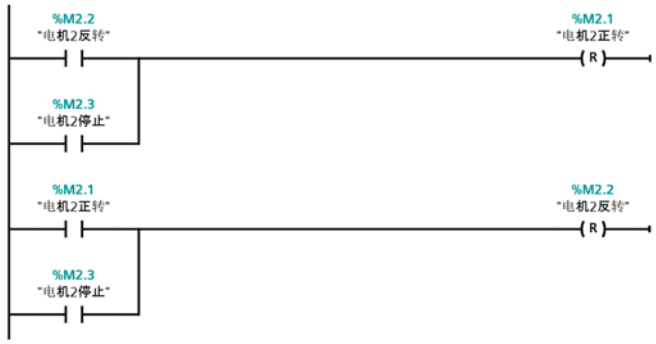

Fig.9. Motor 2 Forward And Reverse Rotation And Stop Control

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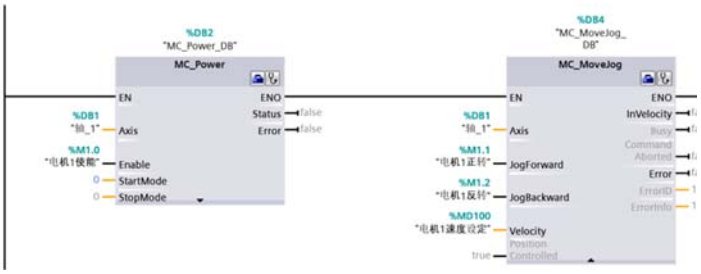

FIGURE 10 MOTOR 1 ENABLES FORWARD AND REVERSE CONTROL

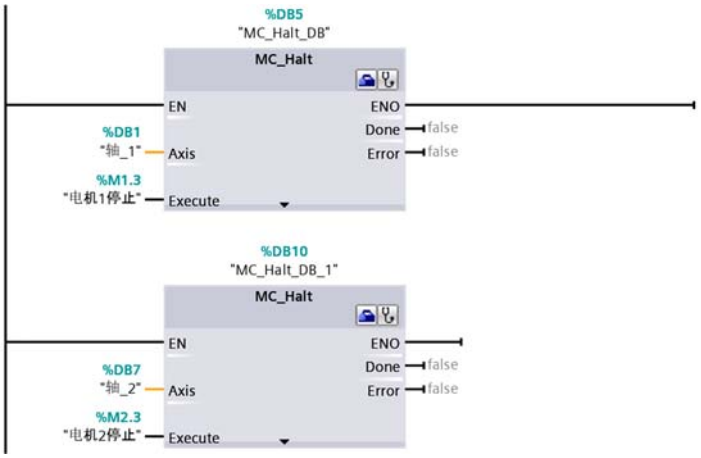

FIGURE 11 MOTOR STOP CONTROL

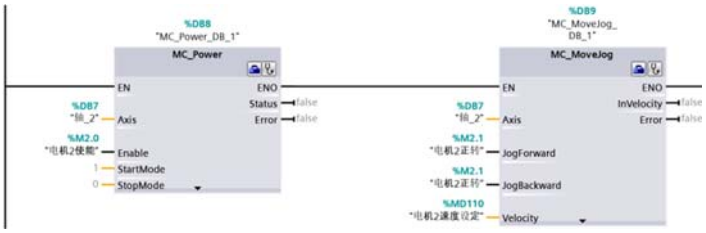

FIGURE 12 MOTOR 2 ENABLES FORWARD AND REVERSE ROTATION CONTROL

4.3 *EXPERIMENTAL DEBUGGING*

The walking and mechanical arm swing of the plant protection trolley are controlled by touch screen KTP700basic PN, and the designed touch screen control panel is shown in Figure 13 below [7], and the test is carried out on the test bench, the test bench is shown in Figure 14, after test verification, the designed electrical control system hardware wiring diagram, PLC control program, touch screen control interface can meet the walking speed of the plant protection trolley and the swing speed of the mechanical arm, the direction, Rotation control requirements, to achieve the expected design effect.

FIGURE 13 TOUCHSCREEN INTERFACE

FIGURE.14 TEST BENCH

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