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Design and Implementation of Weeding Robot Pulling Weeds

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ABSTRACT. *The weeding robot is mainly controlled by STM32C8T6 micro-controller chip and the end of the weeding actuator to control the machine. This paper mainly introduces the overall design of the external structure, hardware and software of the weeding robot. The movement mode of the weeding robot adopts wheel structure and uses high-power driving circuit to drive. A six degree of freedom manipulator is used at the end of weeding, and the length of the manipulator is adjusted according to the requirements of the degree of freedom. In the control system, STM32CT6 micro-control chip is used as the control part of the whole weeding robot, the motor adopts the high-power motor with the ultimate torque of 91kg, and the steering gear on the mechanical arm adopts JX digital steering gear. Through software programming and later debugging, the robot's straight, left turn, right turn, weeding mode action is realized.*

KEYWORDS: *weeding robot; single chip microcomputer; weeding pattern*

1. Introduction

Agricultural production activities are the most basic and important production activities of human beings [1]. Agricultural production is for human beings to obtain living resources and means of production. The development history of agricultural production technology is, to a certain extent, the epitome of the development history of human science and technology. There are about 3000 species of weeds in the world, of which 1800 can affect crop yields [2]. Field weeds compete with crops for water, nutrients and sunlight, which will affect the growth and development of crops, resulting in the reduction of yield and quality, so it is necessary to carry out field weeding. Manual weeding has high labor intensity and low efficiency, and the weeding machinery spraying rust remover, regardless of whether there are weeds or not, will cause high cost and environmental pollution if excessive spraying [3].

Agricultural robot has replaced the role of human in agricultural production activities to a certain extent. The use of agricultural robots not only reduces the manpower input and the cost of agricultural production, but also reduces the use of

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pesticides and chemical fertilizers, reduces environmental pollution and improves the quality of agricultural products [4].

According to the specific environment characteristics and weeding methods, the structure and control system of traditional agricultural weeding robot are designed. The proposal of agricultural robot system with open structure provides a new idea for solving the current development problem of agricultural robot [5]. In this paper, the overall scheme and body structure of weeding robot, the end effector and the work of weeding mode in farmland are designed and studied.

2. Structure Design and Assembly of Weeding Robot

In this design, herbicides are used to work in farmland and other field environments. Because of the particularity of the working environment, in addition to the need to maintain the machine, the rigidity of each component to meet the working requirements, but also to ensure that each connection part can't relax. The structure of herbicidal robot is mainly composed of rudder frame, U-arm, L-arm, small disk, ring and disc. All the mechanical parts are machined by ordinary carbon steel with a thickness of 2mm. The surface of the robot is painted to prevent oxidation. The connection between the chassis and the other parts is fixed by vermicular wire. The main components of the manipulator are 0-shaped arm, L-shaped silent and camel machine. The steering gear is connected with U through metal steering plate and cup bearing to protect the steering gear. In the farmland weeding mode, the clamping end is selected as the end actuator, and the holding end is provided by the steering gear to control the opening and closing of the master device, so that the weeds can be removed accurately. Its explosion view is shown in Figure 1.

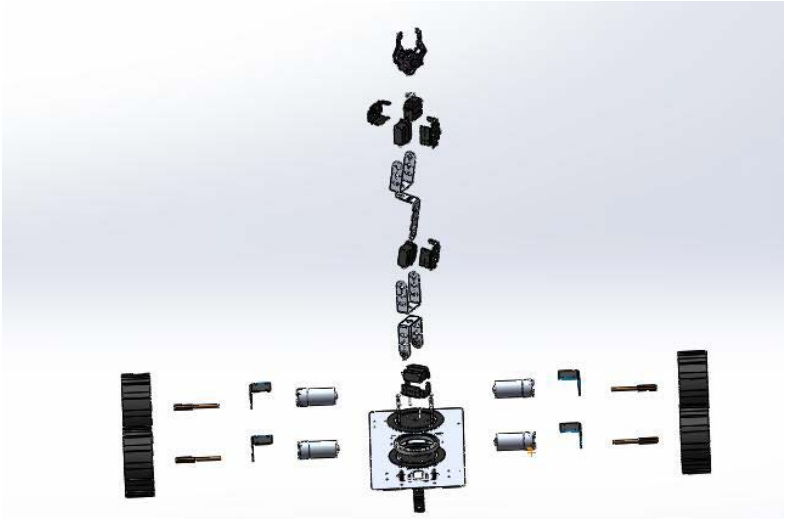

Figure. 1 Explosion view of herbicidal robot.

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3. Control System Module

The control system includes the micro-controller minimum system, voltage regulator module, motor drive module, steering gear signal Isolation module, bluetooth interface and motor Interface. The minimum system of STM32F103CT6 serves as the main control module, which controls the motor module's motion by receiving and processing signals from the sensor module and the power module. The regulator module stabilizes the power supply voltage to the specified voltage value and supplies it to different circuit modules for use. As an external action device, the dial - code switch selects the working mode when the weeding robot is started. The isolation module USES the isolation chip P181 as the communication bridge between the SCM and the steering gear to prevent the external devices from pouring large current back into the SCM. The sensor can be used to obtain various information from the outside, and the information will be digitized and transmitted into the single chip microcomputer. In the program of the single chip microcomputer, according to the external information transmitted by the sensor, the weeding robot can be calculated, judged and controlled to complete a series of work.

4. Hardware Part

In this part, hardware circuits of weeding robot are designed, including power module, voltage regulator module, dial code switch module, signal isolation module and sensor information acquisition module.

The minimum system of the designed master control module STM32F103CT6 includes the main chip encapsulated as THE LQFP48 single chip, an output LED lamp and a serial port download interface. This micro-controller minimum system has 35 GPIO ports and can be completed by calling library functions, that is, many functions to meet the needs of the weeding robot.

The voltage regulator module includes 5V regulator module and 3.3V regulator module. To stabilize the power supply voltage to the specified voltage value for use by different circuit modules. The 5V voltage regulator module is shown in Figure 2. The 5V voltage stabilizer module USES lM2940-5 voltage stabilizer chip, whose output voltage is fixed. In order to visually see the output of the voltage stabilizer chip, an LED light is set at the output end as the external display. If the light is on, the chip works normally; if the light is not on, the chip does not work.

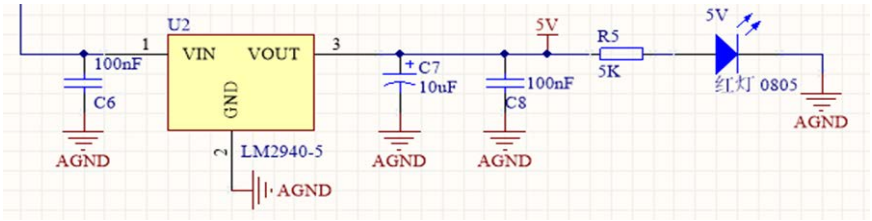

Figure 2. 5V Voltage regulator module Figure.

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3.3V voltage stabilizing module USES AMS1117-3.3 chip. In the design, the input voltage is set as 5V after voltage stabilization, and the output is the standard 3.3V voltage. In this module, external capacitors and resistors act the same way on the LM2940-5. The circuit diagram of 3.3V voltage stabilizing module is shown in Figure 3.

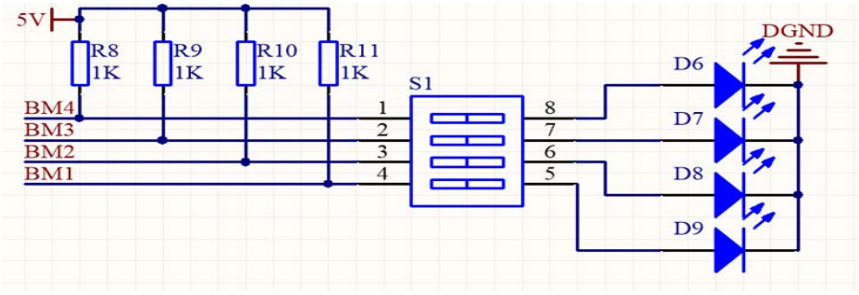

Figure 3. 3.3V Voltage regulator module Figure.

As an external action device, the dial-code switch inputs certain instruction signals to the MCU through manual adjustment. You can choose the working mode when the weeding robot starts. The dial - code switch circuit is shown in Figure 4. In the dial-code switch circuit, circuits R8, R9, R10 and R11 are used as pull up resistors, and led D6, D7, D8 and D9 are used as dial-code switch mode display.

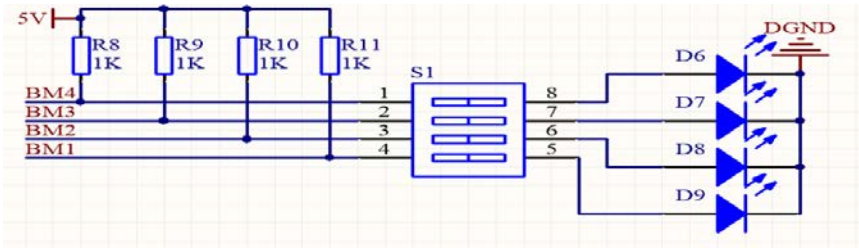

Figure 4. Dial-code switching circuit

An isolated device is needed between the MCU and the high-power drive to transmit the output signal of the MCU in one direction to prevent the external device from pouring large current back into the MCU. In this design, the isolation chip P181 is selected as the communication bridge between SCM and steering gear. P181 chip is a kind of optocoupler isolation chip, which realizes the unidirectional signal transmission through the high and low level relationship between infrared led, LED and photosensitive conductor tube. The internal schematic diagram of P181 chip is shown in Figure 5

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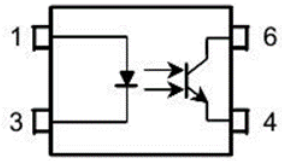

Figure 5. Internal schematic diagram of P181

The optocoupler signal isolation circuit is shown in Figure 6. The PWM signal of the single chip is output to port 1, and the 5V pulse with the same frequency and duty ratio is output at the signal end of the steering gear. The difference is that the output voltage is directly derived from the output voltage of LM2940-5, which is stronger in driving ability than the direct output voltage of the single chip.

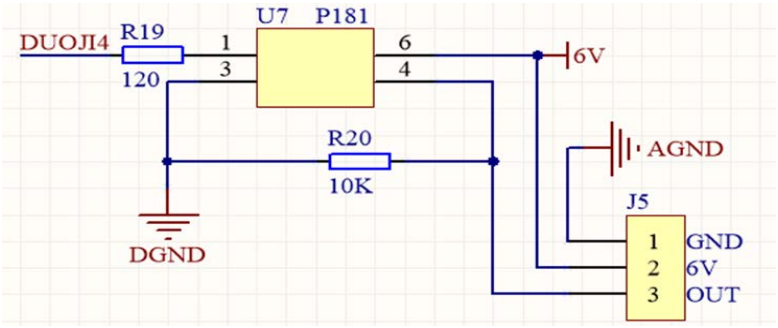

Figure 6. Optocoupler isolation circuit of steering gear in circuit design

5. Software Part

5.1 Software Process Design

The core control chip used by weeding robot is STM32C8T6 MCU with medium capacity. Its chip has a program memory of 64K, enough to accommodate all the control functions of the weeding robot. It USES C language as the programming language and KEIL software as the compiler. KEIL can generate the HEX file in the folder during compilation. Select the Hex file from the serial port download software FlyMcu, download it to the MCU, and press the reset key to run the program. In the set of engineering parameters, the SCM model needs to be set correctly, otherwise it will be wrong in use. In addition to setting parameters, you have to choose the boot file. The Flash of STM32C8T6 is 64K, which is a medium size chip. In the selection, you need to select the startup_stm32f10x_md.s startup file.

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5.2 The Design of the Weeding Pattern in Farmland

In the field, weeds and crops often exist at the same time. It is necessary to locate and remove weeds during weeding. It is necessary to use cameras to distinguish and locate crops and weeds in farmland using environment. After the MCU （Microprogrammed Control Unit）gets the positioning information, it drives the end of the mechanical arm to the designated position to remove the weeds.

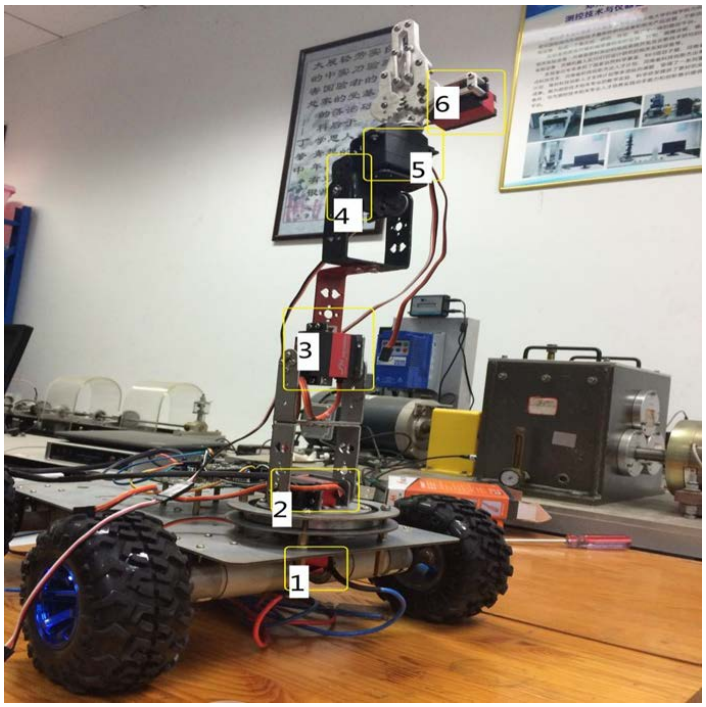

Figure 7. Six steering gear positions in the field weeding mode

In the field weeding mode, a total of 6 Steering Engines are required, as shown in Figure 7. In the figure, the boxes are successively No.1, No.2, No.3, No.4, No.5 and No.6 Steering Engines from bottom to top. During a cycle of weed removal in the farmland, the position of the No. 1 Steering Gear does not move. Weeds are removed by the combined action of No. 2, 3, 4, 5, and 6 servos.

The essence of controlling the movement of the robotic arm is to control and adjust the angle of the Steering Gear. Taking into account the characteristics of the sports mode and the torque of the No. 2 servo, after the actual test, the high level time of a PWM pulse signal period that controls the No. 2 servo is set between 1400 μs and 2000 μs. Set the angular movement range of No. 2 servo to 36°; The high level time in one period of the PWM pulse signal for controlling No. 3 servo is set

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between 1400μs and 1800μs; The angular movement range is also 36°; The high level time in one PWM pulse signal cycle for controlling No. 4 servo is set between 1400μs and 2300μs, and the angular action range is 81°; The effective action angle of the No. 5 servo is 90°, so only need to set a PWM signal in the high-level duty range of 1000μs to fully cover all the effective angles. In the design, the high level time in one PWM pulse signal cycle of the No. 5 servo is set between 1300μs and 2300μs, and the angular action range is 90°.

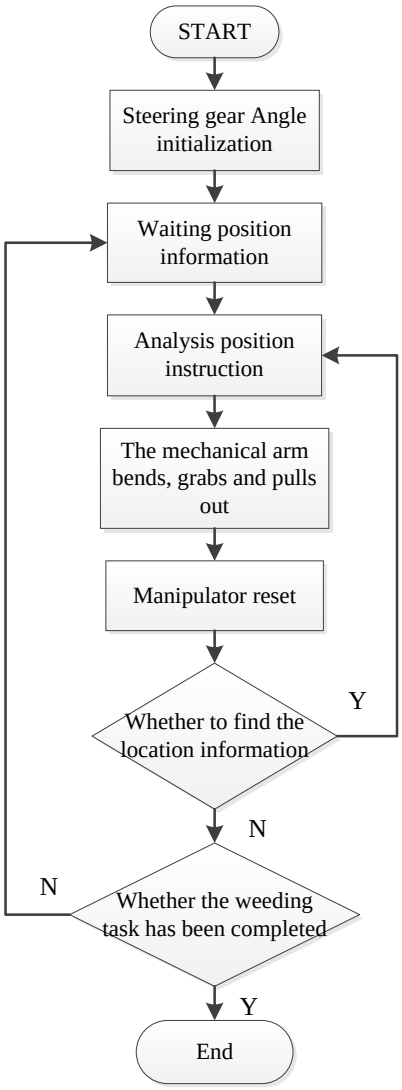

Figure 8. Process flow chart of weeding mode

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Table 1 The value table of the Corresponding Capture Compare Register of the servo during weeding

Steering Gear	NO.2	NO.3	NO.4	NO.5	NO.6
1	1400	1400	1400	1400	1400
2	1430	1420	1445	1400	1400
3	1460	1440	1490	1400	1400
4	1490	1460	1535	1400	1400
5	1520	1480	1580	1400	1400
6	1550	1500	1625	1400	1400
7	1580	1520	1670	1400	1400
8	1610	1540	1715	1400	1400
9	1640	1560	1760	1400	1400
10	1670	1580	1805	1400	1400
11	1700	1600	1850	1400	1400
12	1730	1620	1895	1400	1400
13	1760	1640	1940	1400	1500
14	1790	1660	1985	1400	1600
15	1820	1680	2030	1400	1700
16	1850	1700	2075	1400	1800
17	1880	1720	2120	1400	1900
18	1910	1740	2165	1400	2000
19	1940	1760	2210	1400	2100
20	1970	1780	2255	1400	2200
21	2000	1800	2300	1400	2300
22	1970	1780	2255	1400	2200
23	1940	1760	2210	1400	2100
24	1910	1740	2165	1400	2100
25	1880	1720	2120	1400	2100
26	1850	1700	2075	1400	2100
27	1820	1680	2030	1400	2100
28	1790	1660	1985	1400	2000
29	1760	1640	1940	1400	1900
30	1730	1620	1895	1400	1800
31	1700	1600	1850	1400	1700
32	1670	1580	1805	1400	1600
33	1640	1560	1760	1400	1500
34	1610	1540	1715	1400	1400
35	1580	1520	1670	1400	1400
36	1550	1500	1625	1400	1400
37	1520	1480	1580	1400	1400
38	1490	1460	1535	1400	1400
39	1460	1440	1490	1400	1400
40	1430	1420	1445	1400	1400
41	1400	1400	1400	1400	1400

The motion cycle also contains 41 states, and the mechanical arm performs a pull out action every time, which is different from the Steering Gear in front. When a position signal is triggered, the Capture And Compare Register corresponding to

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each servo will read the data in the table once. If there is no position signal, the Steering Gear remains in the initial state.

4. Conclusion

In this paper, the overall structure of the robot design, control system design, as well as the characteristics of weeding robot and the main technology involved in the summary, complete the overall planning layout of the robot. The hardware part explains the selection of each module, the software part explains the working principle of the robot according to the process of the program, and introduces the method of the function of the weeding mode in detail, which provides a reference for the future design work, and proves that the design scheme is feasible.

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