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An Intelligent Robot System for Spraying Pesticides

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Abstract: In order to reduce pesticides in agricultural production caused by direct contact with the human body injury, and improve the efficiency of agricultural spraying operations, this paper proposes the design of intelligent WiFi wireless controlled spraying pesticides robots. For monitoring the microcontroller core, a wireless router for the network connection point is employed. The camera captures video, Android phones and smart monitoring system operation. Test results show that the design realizes spraying pesticides by robot to replace staff job, and achieves good results..

Keywords: Robot, wireless controller, spraying.

1. INTRODUCTION

The use of pesticides in agricultural production is an insecticide, sterilization, pest or weed killing drugs for the prevention, eradication or control hazards in agriculture, forestry, disease, insects, grass and other harmful organisms and purposeful regulation of plant growth of chemicals [1]. Traditional manual pesticide spraying operations is full of direct exposure to the pesticide liquid work environment, great harm to human body. Spray robot can effectively isolate the drug in direct contact with the human body in pesticide spraying process, but because of the constraints of large agricultural robot delicate and complex nature of the job objects, the complexity of the operating environment and the operation target price particularity and development issues such as slow [2-7]. Wireless control spray robot can find a breakthrough on these issues.

Wireless control applications in real life appear more and more, especially in agriculture. Industry plays a vital role. WiFi (Wireless Fidelity) with its high transmission speed, flexibility and mobility, etc., in the smart home, industrial control, mobile handheld devices and other needs of the growing number [8-10]. Intelligent design using WiFi wireless control spraying robot camera to capture video, send video data to Android mobile phone display, mobile phone via a wireless WiFi spray to control the robot work. Replaced by a robot manually spraying operations, reduce pesticide harm to people, reducing the manual labor staff and improve working efficiency [11-12].

2. THE BASIC PRINCIPLE AND SYSTEM BLOCK DIAGRAM

Design of high-speed wireless access and transmission characteristics of WiFi-based, wireless router as a network connection point, the camera for video capture, video data transmission to the wireless router, wireless router via WiFi network to send data out, Android smart phones connect to a wireless router WiFi network, a wireless router receives video data and displayed on the phone, according to the surroundings of the robot remote control. Instruction issued on the phone can also be connected via the serial port with SCM router, router, the received instructions to send the phone to the microcontroller to achieve a robot on the phone to a wireless remote control and video surveillance transmission to the router *via* WiFi.

Set by the system control section, WiFi module, mobile devices, video capture module, the car module, driver module, spray module and infrared obstacle avoidance module, system block diagram showed in Fig. (**1**). Android smart phones by the operator on the wireless router connected to WiFi access, control terminal open the phone application, you can see the video camera captured, according to the operator and then sent to the mobile phone display video content via mobile phones touch keys robot, operating instructions camera rotation and spraying such action, the wireless router to receive instruction and pass through the serial port to the microcontroller, the microcontroller received instructions to control the robot perform the appropriate actions. Traffic channel on both sides of the crop spraying operations, the robot may control the spraying direction of the spray head, according to the height of the crop; the height of the spray can be modified to achieve the pesticide spray function. Whether the robot in front of the spray module detects an obstacle, an Obstacle then retreats a short distance and obstructions to prevent collisions.

3. HARDWARE DESIGN

3.1. System Control Sections

System control in part by STC11F32XE microcontroller as the core controller, STC11F32XE is a new generation enhanced Acer Crystal Technology, Inc. 8051, a clock /
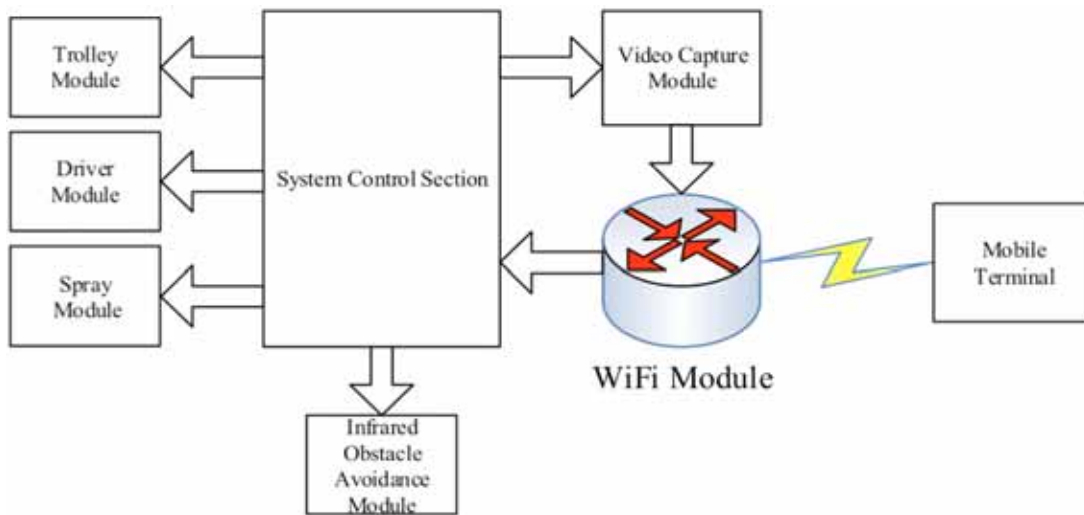
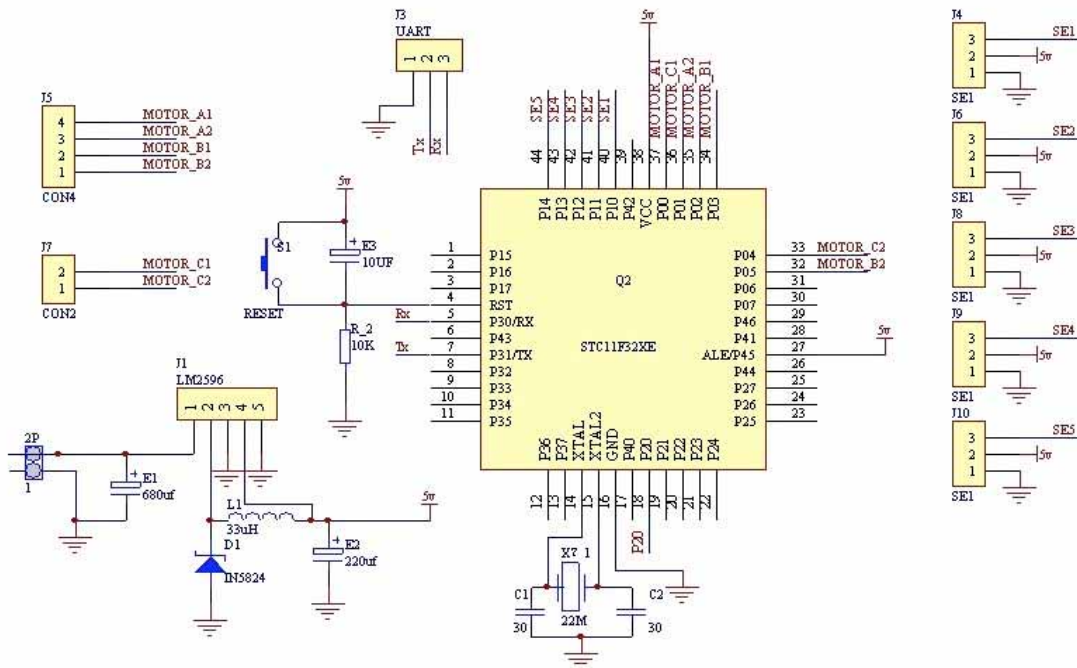**Fig. (1).** A system block diagram.

Fig. (2). System control section schematic.

machine cycle, with high-speed, high reliability, super anti-jamming capability, low power consumption characteristics. SCM and routers are TTL level, microcontroller TX and RX pin TTL serial port pin connection and wireless router; leads to six I/O control L298 motor drive, drive motor and control groups trolley lift motor; lead five I/O control 5-way steering; power supply section is integrated LM2596 switching regulator chip, with perfect protection circuits, power utilization, requires minimal external devices that can provide more current 3A ensure circuit normal power supply. Providing regulated power microcontroller and servos has been figured Schematic in Fig. (**2**).

3.2. Trolley Modules

As a carrier trolley, carrying the liquid jet and the entire hardware system, the body part is tracked chassis of the vehicle, the configuration four motors; motor twenty-two approximately parallel to improve the driving ability. Use crawler chassis of the vehicle can be a step in a variety of composite cement road pavement, mud, gravel, pavement, grass and the like. L298 car motor power motor drive circuit by driving the car, using a nickel - cadmium (Ni-Cd) as a power source, provides a strong impetus to the car.
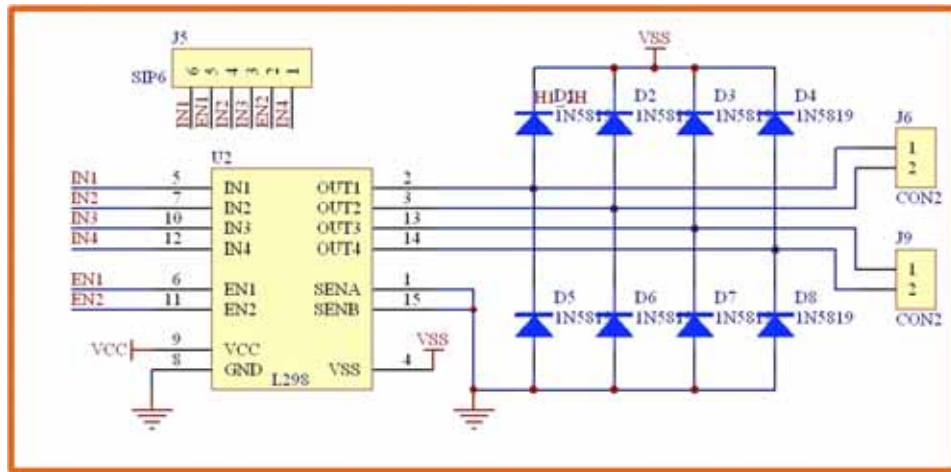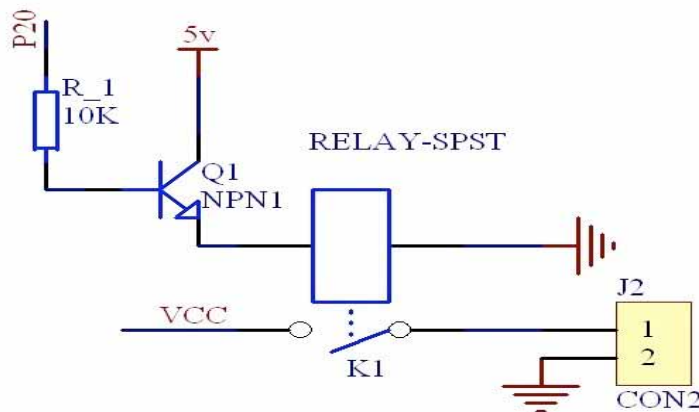
Fig. (3). L298 motor drives the circuit diagram.

Fig. (4). I/O control relay circuit.

3.3. Driver Modules

DC motor driver using L298 driver chip, the chip is a high-voltage high-current two H-bridge full-bridge drives, the drive circuit has six controls terminal (2-enabled client and four control sites), there are four output ends, a driving circuit may drive two motors. I/O and control port connected to the microcontroller L298, a program to monitor the motor's story, reverse and stop. L298 motor drive circuit is shown in Fig. (**3**).

3.4. Spray Modules

Spray module consists of a spray head, pumps, relays, Servos, screw fixation rod and DC machine. In the back of the car create a lifting device, using an ordinary DC motor using L298 high-power motor drive circuit. Spray the screw nut and platform are secured together, the other end of the platform can be sprayed on the other a vertical rod fixed to the slide, driven by the DC motor to rotate the screw may be moved up and down to control the spray platform. Screw length 38cm, platform lift spray distance is 35cm, the car height 17.5cm, install the motor, spray the platform increases

to the height of the highest point of the spray head is 65cm, the height of the lowest point is 30cm.

Steering model is MG995, metal gears, double ball bearing, 5V power supply, the rotation angle 0-180 degrees. A signal line to generate a PWM waveform is monitored by the microcontroller, rotate different angles depending on the duty cycle of the PWM servo. Install a steering gear, steering gear and spray the spray head is fixed on the platform together, servos to control the rotation of the spray head is turned by the microcontroller's PWM waveform control.

A microcontroller I/O control transistor base, through the transistor drive relays, pumps and power through the relay is turned on, the pump suction end is connected to the bottom of the bottle, and the other end connected to the spray head, spray from the spray head, the microcontroller I/O port can control the working status of the pump. I/O control circuit diagram showed in Fig. (**4**).

Another MCU I/O port control transistor base, through the transistor drive relays, relay pumping pump power is turned on, program-controlled robot to drug infusion syrup bucket.
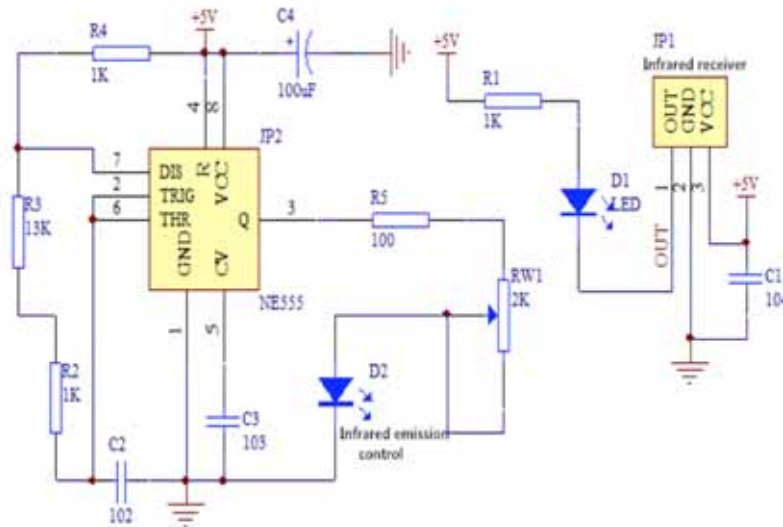
Fig. (5). Infrared obstacle avoidance circuit.

3.5. Video Capture Module

Video capture module comprises of a camera and steering components. Camera requiring a free driver camera directly connects to a wireless router via USB. To build the car in front of a camera mounted control platform, the platform installed below MG995 steering gear, steering gear and the platform together, the rotation axis and the camera base servos together. Adjust the car in front of the steering gear 90-degree angle, through the microcontroller to generate a PWM waveform control servos rotating axis in the range of 0-180 degrees to the axis of rotation servo drive means for rotating the camera, you can shoot the surrounding environment. The camera is joined via USB cable and wireless router, the video data transmission to the wireless router.

3.6. WiFi Modules

WiFi module uses 150M Mini 3G wireless router TL-703N, 150Mbps wireless local area network transmission rate, 5V power supply, there is an external USB camera interface, an external TTL serial port connection, support OpenWrt [13], small, stable wireless transmission performance .

Wireless router is a router with wireless coverage capabilities. In a wireless network, the transmission rate and the environment are closely related to transmission of the data is performed by the signal in the actual use environment, more or less will cause a transmission signal interference. For signal coverage, typically within 50 meters indoor range is a better wireless signal outdoors in general can reach 100-200 meters. Wireless router signal strength is highly affected by the environment.

Apart is opened source routing firmware. Apart package management provides a fully suitable file system. Wireless router through the brush into the open source OpenWrt system that allows the router to get a running Linux system, a small computer, is a reliable chips utilizing a miniature router Linux systems. With this system, the wireless router you can install a variety of applications, drivers, wireless router as a platform, users can load according to individual needs USB camera, network cards, sound cards, etc. equipment. Routers are generally reserved for TTL serial port, TTL serial port is used to debug or brush used, TTL serial port is a serial communication in general is three lines (transmit data -TX, receive data -RX, ground -GND), TTL 5V level are generally less common microcontroller serial port router and are TTL level, only the same type of level can communicate with each other; otherwise unable to communicate properly, there may burn out due to excessive voltage circuit.

Wireless router system to load one pair of USB camera video encoding program, and then through the WiFi network to transmit video data to the phone, on the phone through the video decode and display video on your phone, so you can see the camera via mobile phone captured video images. By loading Ser2net software systems in the wireless router, wireless router via a TTL serial port can put instructions from WiFi to serial output channel module, TTL serial cable attached to the microcontroller TX and RX, and single-chip communication.

3.7. Infrared Obstacle Avoidance Modules

Infrared obstacle avoidance circuit of the NE555 circuit makes infrared emission control and infrared receiver components. Infrared receiver has three pins -VCC. GND, OUT, demanding a 5V power supply, infrared receiver receives the infrared signal of 38KHz. Infrared receiver can amplify weak signals processing. The output pins high when the infrared signal is shown, received infrared signal output low. The microcontroller output pin and an I/O connection, the microcontroller determines that the I/O can identify high and low infrared signal is received, that if there is an obstacle in front. NE555 circuit gives rise to signal using a carrier signal as 38KHz infrared emission tube, infrared emission. Current face obstacles, infrared signal is reflected back to the receiver tube obstruction, receiving tube is transferred to a minimal level, single-chip processing. Fig. (**5**).
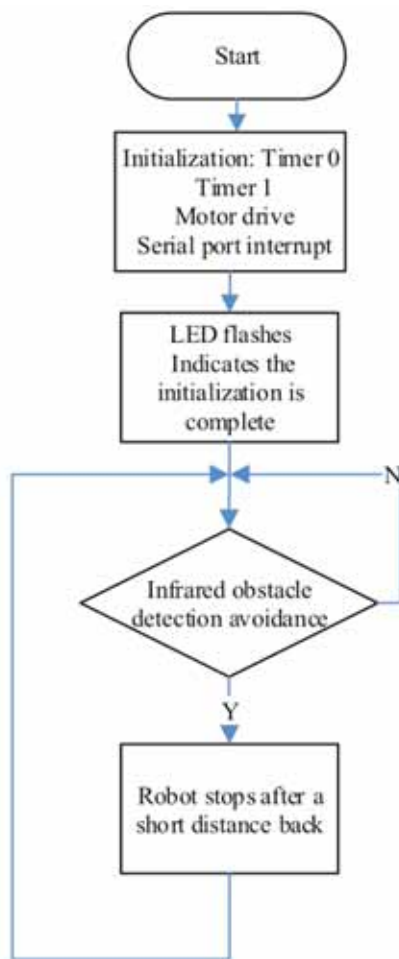
Fig. (6). Main program flow chart.

4. SOFTWARE DESIGN

4.1. Lower Computer Program Designs

Lower computer program design is at the heart controller STC11F32XE microcontroller programming in C language as a development language, to achieve lower bit machine timers, serial ports, and each I/O initialization, write microcontroller serial interrupt service routine, received instruction judgment and execution. The main program of the system flows charts shown in Fig. (**6**).

Interrupt service function [14]: Processor after receiving the order to stop the current task to deal with the "urgent", can be viewed as a service. The interrupt service routine is set to write programs need to deal with "urgent."

CPU is executing the program. Suddenly received orders to proceed to deal with something immediately after the completion and return program execution continue just followed the original program execution process. This process is interrupted.

Program to open the serial port interrupt function, when the microcontroller serial data is received, an interrupt request to the CPU, CPU responds to the interrupt, the current

program to mark, then jump to the serial interrupt service routine entry address to begin execution of an interrupt program, such as Fig. (**7**).

4.2. PC Programming

PC control software is an android phone. The PC is designed to create an android application in the Eclipse development environment. PC is communicating through TCP (Transmission Control Protocol) / UDP (User Datagram Protocol) communication and routers to send data to a wireless router using the Socket connection, the PC is the Client (client) mode, the router is Server (server) mode. Phone is the client, the phone sends commands through the different buttons different commands sent to the router via WiFi, the router sends video data to the mobile consumer, mobile phones and routers to achieve a two-way data exchange.

Control software development in the Eclipse development environment designed to Java language-based, object-oriented development approach. Display interface design system, a first add the video decoding processing function, the wireless router receives the encoded video is decoded, the whole screen is displayed, the control keys to add the appropriate interface, respectively, to control the production of a response function, the response function preparation of data processing functions, and send commands. Adding camera features in the design, you can set the video address and view the corresponding button to provide commands. Phone video interface is shown in Fig. (**8**).

On the phone you can see the camera shooting video, you can rotate the camera by sliding the control bar to the right of control, observe the surrounding environment; the surrounding environment based on the video display, four touch the lower left corner of the front and rear left and right direction keys can control the robot walk in designated location; ready to begin spraying operations, observe the height of the spray object, up, down two buttons to adjust the spray head to the right height; bottom right and left turn buttons can control the spray direction, in order to protect the device, when the spray head is rotated to the maximum angle, turn left and right buttons on the spray head can not continue for more deflection; after adjusting well, spray the top right of the switch can start spraying, click again to end the spray switch spray. There is a middle of the uppermost pumping switch, there is no liquid medicine barrel, when the suction tube into the drug pool, it could be clicked the button to the water bucket, and click again to stop pumping. Top in the middle there are a WiFi connection and testing of camera lights.

5. TEST RESULTS AND ANALYSIS

5.1. Working Time Test

Working time test carried out in the nursery, the robot installed sprayed with water, connected to the robot Android phone wireless router WiFi network, using a mobile phone to control the robot into the garden in the middle of the concrete floor about 30cm width of the channel, according to the environment around the spray head adjustment to a suitable
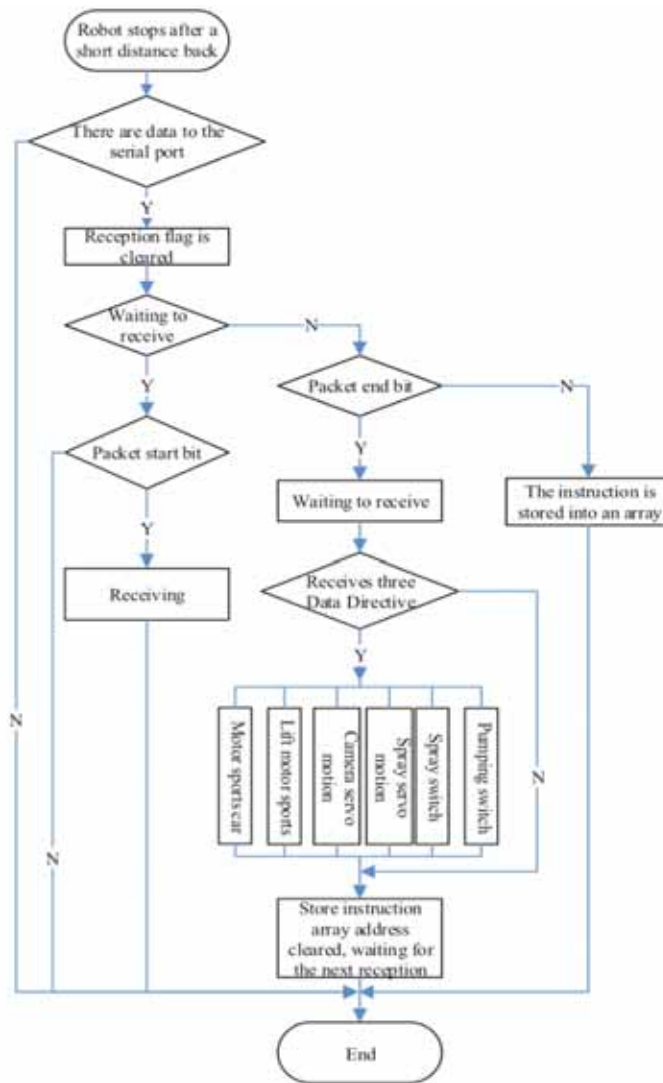
Fig. (7). Serial interrupt service routines.

Fig. (8). Phone video effects.

height and began to open the pump spray job. Robot thinks i need a nickel - cadmium (Ni-Cd) batteries and a lead-acid battery powered. Nickel - cadmium battery to the car during the work group and the left motor supplies power, lead-acid batteries to provide the core of the system board and the pump power, the experiment the robot can continue to work in one hour.

By the time the test experimental robot, the robot power supply system to ensure the robot has relatively long working hours, to guarantee the completion of certain spray robot workload. However, if you want to get a longer working time, you can improve the motor-driven mechanical structure, reducing the friction loss, the use of more efficient pumps and other ways to work longer hours.

a

b

c

Fig. (9). Robot performance testing in a variety of road.

5.2. Robot Performance Testing In A Variety Of Road

Robots can be on concrete, mud, gravel, grass driving, you can speed humps on the road, you can function on a 30-degree slope. Cement or mud in the plane of the floor can be kept fast walking speed, the robot can be smoothly gravel and grass by the robot which is the main advantage of the use of the crawler body, and the crawler belt vehicle can enhance the adaptability of the ground complex. The width of the robot body 22cm, flexible walking adaptable has been shown by Fig. (**9**).

By road adaptive testing experimental robot, the robot on a variety of complex terrain encountered in the actual work environment can be a good deal. Robotic crawler body is increased and the ground contact area, can be solved in the

conventional wheeled vehicle other loose gravel and grass ground running wheel and cannot be easily subsidence problems. When the ramp driving motor is enough power to climb, but the slope is greater than 40 degrees when the lift frame due to the higher center of gravity backwards and cause can't travel, can be optimized to increase the nozzle lifting frame and chassis frame resolved.

5.3. Video Shooting Range

Webcam Video Capture is a key operational aspects spraying robot. Test the camera shooting angle on the grass in front of the car is 90 degrees, the phone can control the camera to photograph video in the range 0-180 degrees. Watch videos in the phone, you can very well be the route of

a

b

c

Fig. (10). Video shooting range.

the robot environment, to control the car and walk forward in accordance with the actual situation of the plants was sprayed job. The actual transmission test operation found that when the distance between the phone and the robot control terminal to get a good video display effect within 40 meters, within 70 meters of video updates slow, but the end of the phone to control the robot control commands are still normal Fig. (**10**).

Video transmission test, the robot is installed 180 degrees can adjust the camera to get a larger visual range, smooth video transmission 30 m distance to meet the actual operation of the application, the camera real-time transmission to the phone intuitive video shown to the staff of the real-time operation of the robot remote there are a great help, reducing the staff misuse of the robot.

5.4. Spray Range Test

Spray test in the nursery, the pumps work force dedicated, pesticide spray nozzle of the spray water can get good results, fog can be evenly sprayed on the seedlings, high working efficiency. Nozzle height adjustment saplings according to the appropriate height, control spray head turned to the left, to the left of the completion of the spray saplings, then stop spraying, the spray nozzle to the right of the open switch spray. Video control car moves forward, continue to move forward spray job Fig. (**11**).

Measuring the distance of the farthest injection 130cm, the spray angle can be controlled at 30-150 degrees, an angle of the spray area of 0.88m2. You can make saplings drenched wet leaves, spray and humidity appropriate to

a

b

Fig. (11). Spray range test.

achieve the spray job requirements. Bottle was full of water (1.8L), a bottle of water after spraying took 3 minutes 07 seconds, indicating that much spray volume per unit time.

Spray test results, fine mist spray nozzle uniform mist falling on crop moisture evenly appropriate. Meanwhile, the vertical angle of the nozzle can achieve great height 35cm plane rotation and movement in the distance can be made on both sides of the robot 130cm full coverage spray job. To get a better spray effect, you are required to spray the robot's operating personnel to be flexible in place. This can also serve as automatically adjusted by the system to determine the concentration of the spray system optimization in the future.

CONCLUSION

An intelligent robot system spraying pesticides, to control the robot through a wireless alternative to manual completion of crops spray test, reducing direct exposure to pesticides and the human body, reduce pesticide harm to people, and improve production efficiency. In STC11F32XE microcontroller as the core controller, anti-interference ability, low prices. By good, can be different terrain, different heights crops by spraying operation tests show that a certain protective, practical, mobile robot, better spray effect at the right working environment, such Its low cost, ease of handling and easy maintenance and other characteristics of individuals with a broad market in agricultural production.

CONFLICT OF INTEREST

The author confirms that this article content has no conflicts of interest.

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