ISSN 2706-655X Vol.6, Issue 3: 177-183, DOI: 10.25236/IJFET.2024.060323

Saline Alkali Land Restoration Machinery Based on Visual Recognition

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Abstract: *Aiming at the difficulty of saline-alkali land restoration and the single way of restoration, this paper designs a saline-alkali land soil restoration and vegetation planting machine, and carries out function-oriented circuit design, so that the machine can realize vegetation planting and play the effect of windbreak and sand fixation. The machine uses K210 as the upper computer for target recognition, and Arduino Mega as the lower computer to respond to the signals of the upper computer and control the mechanical work. The machine is conducive to promoting the development of soil remediation and vegetation planting machinery in saline-alkali land, and has good ecological benefits and promotion value.*

Keywords: *ecological restoration, Arduino, K210*

1. Introduction

Our country is a populous country, national security and food security are closely related, according to the statistical data show[1]. From January to September 2023, China imported 11.99 million tons of grain, up 5.5% year on year. With the increase of the population in our country, the contradiction between the population and the usable land insufficiency has become increasingly prominent. According to the relevant data, the area of saline alkali land in our country has reached 99.14 million hm2[2]. And every year there are large areas of arable land due to human activities of soil secondary salinization[3]. After consulting relevant reports, we found that saline-alkali land is widely distributed in China with a large regional span, obvious climate changes and great differences in soil conditions, so it is difficult to effectively repair all saline-alkali land through a single technology.

In the past few decades, researchers around the world have conducted a lot of research on soil environmental remediation in saline-alkali areas. Puxiao Liu investigated the case of ecological restoration in Changyi City and summarized the ecological restoration methods of water diversion and flood irrigation and planting green manure crops[4].Huawei Shao developed a chemical amendment that can repair salt-alkali land with different PH values at different concentrations[5]. Shunan Yang studied the deep pine technology to improve the permeability of soil and water and shorten the improvement cycle of saline-alkali land[6]. Weiqiang Li developed a method to reduce the total amount of water-soluble salt in soil by intercropping crops[7]. Qi Zhu put forward the method of in situ engineering radical treatment technology to treat saline-alkali land by increasing the application of biological organic fertilizer[8]. The above studies have some enlightenment for the mechanical device and control system designed in this paper. However, there is currently a lack of a machine that can chemically treat the soil before ecological restoration of saline-alkali land to ensure the survival rate of tree seedlings, so it is necessary to design a new type of machine to complete this work.

Haloxylon ammondendron is widely distributed in desert and semi-desert areas in northwest of our country. Because of its saline-alkali and drought tolerance characteristics, it has become the main tree species in the artificial buffer zone between desert ecosystem and oasis ecosystem[9]. In this paper, the model of Haloxylon ammondendron saplings as the research object, analysis of the morphological characteristics of Haloxylon ammondendron saplings, through the model training to extract the morphological characteristics of Haloxylon ammondendron saplings, and combined with the underlying control of single-chip microcomputer, design a visual recognition based Arduino ecosystem repair machinery. In order to solve the problem of low survival rate of tree seedlings in the process of bioremediation, the program of chemical and biological vegetation restoration is combined with the

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different characteristics of salt content in saline alkali land.

2. Mechanical Hardware System

The hardware of Arduino ecological restoration machine based on visual recognition includes two main parts: K210 development board and Hui Yu seedling car, using USB cable to achieve serial communication.

The seedling truck part of the saline alkali soil restoration and vegetation planting machine uses Arduino Mega2560 as the control board of data processing and movement control to complete the functions of movement, environmental restoration, communication, obstacle avoidance and so on. The seedling truck moves under the control of Arduino control board, and carries out soil breaking, soil composition testing, medicine spreading, seedling planting, soil gathering and other work. When the seedling truck is working, K210 uses the algorithm to identify the target, realize the attitude detection of the seedling, and help the seedling work to complete. Figure 1 is the overall physical drawing of the machine. Figure 2 shows the working flow chart of the machine.

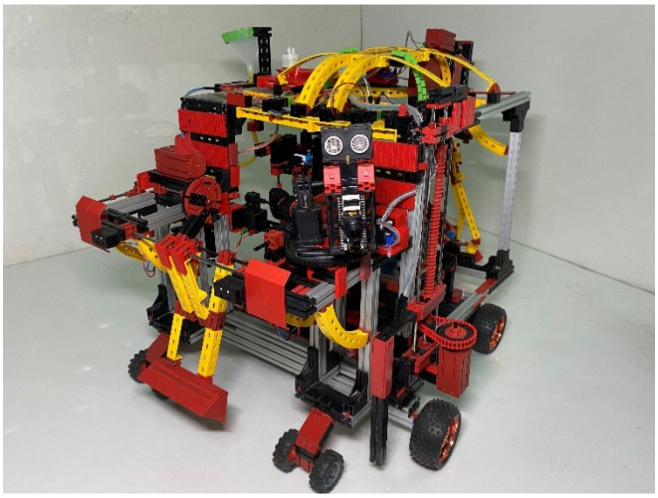

Figure 1: Physical mechanical drawing

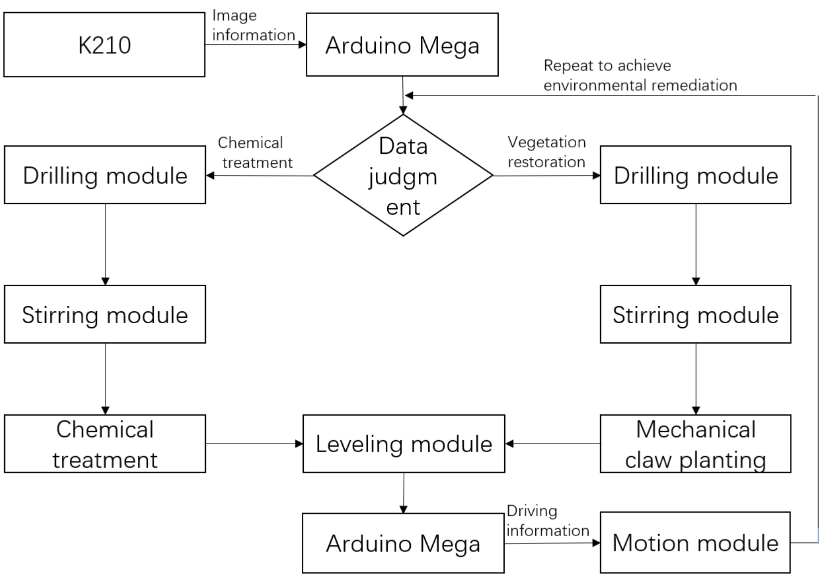

Figure 2: Mechanical work flow chart

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3. Mechanical Control System

3.1. Control System Hardware Design

The circuit hardware system of the machine is mainly composed of ultrasonic module, motor driver module, K210 visual recognition module, voltage regulator module, Bluetooth module, display module, etc. The system design framework is shown in the figure below. Figure 3 is the design diagram of mechanical hardware circuit.

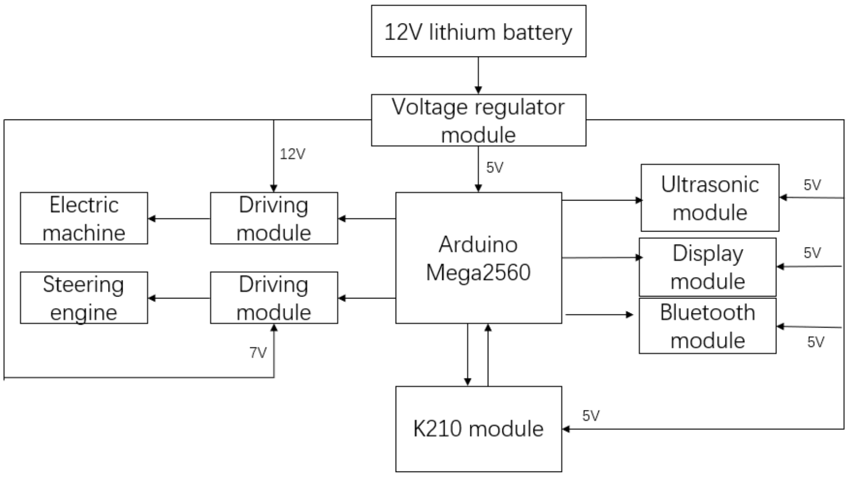

Figure 3: Circuit hardware system design framework

3.2. Control System Software Design

The control system software design uses Arduino Mega2560 as the core board to control each module. K210 is used to identify posture and adjust seedling planting posture, and the two use serial port to communicate. Figure 4 shows the mechanical software design framework.

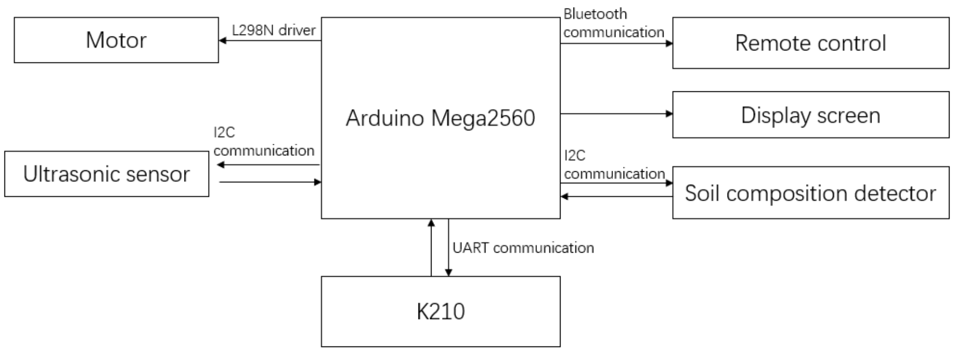

Figure 4: Control system software framwork

3.2.1. Ultrasonic Wave Module

The ultrasonic sensor module uses the HC-SR04 ultrasonic sensor for ranging and obstacle detection. Using the principle of acoustic reflection, the ranging formula can be obtained. Where, S is the distance between the transmitting point and the reflecting point, c is the speed of sound, and it is time.

$$S=c\cdot t/2 \tag{1}$$

Considering the temperature difference change in reality, in order to improve the measurement accuracy, the actual sound speed is often corrected in industrial measurement. c_θ is the sound speed at different temperatures, and θ is the temperature.

$$C_\theta=331+0.6_\theta \tag{2}$$

To sum up, the actual ranging formula of seedling truck can be obtained as follows:

$$S=c_\theta\cdot t/2 \tag{3}$$

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Three HC-SR04 ultrasonic sensors are installed at the front end of the machine, which are respectively installed on the left, middle and right side. Figure 5 shows the mechanical obstacle avoidance algorithm.

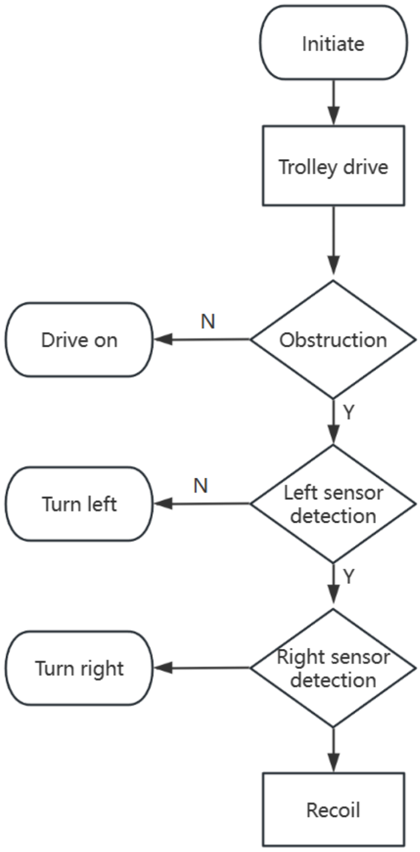

Figure 5: Obstacle avoidance idea

3.2.2. Motor And Drive Module

The machine is driven by double DC motor, and the DC motor driving chip L298N is used to drive the Hui Yu motor. The Arduino Mega2560 program controls and adjusts the PWM signal of the driving motor, changes the output power of the motor, and controls the motor speed used by the machinery. Figure 6 shows the motor and drive module

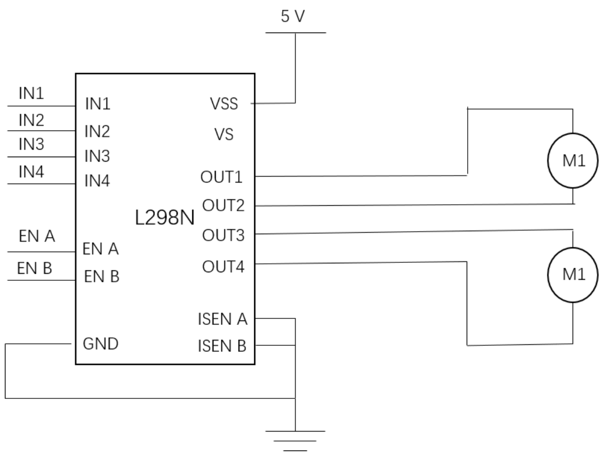

Figure 6: Motor and drive module

3.2.3. K210 Attitude Correction

The visual recognition scheme of this system adopts K210's core neural network accelerator KPU based on independent research and development, and realizes the deployment and application in intelligent ecological scenes with TinyYoLOv2 network model. Firstly, K210 sensor is used to take a

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large number of photos of obstacles such as stones and trees in saline alkali land, and maxihub is used for cloud training. The firmware is burned into K210 and the program is written to detect the attitude of seedlings.

K210 converts the image into HSV format and extracts the top green point (leaf) S and the bottom brown point (root) of the sapling. Use the slope formula to find the slope between two points.

$$K_{sm}=(y_s-y_m)/(x_s-s_m) \tag{4}$$

Use the inverse trigonometric function to find the inclination Angle θ:

$$\theta=\arctan k_{sm} \tag{5}$$

Then the steering gear in the manipulator rotates at the corresponding Angle to put the seedlings into the soil vertically. Figure 7 shows the sapling planting algorithm

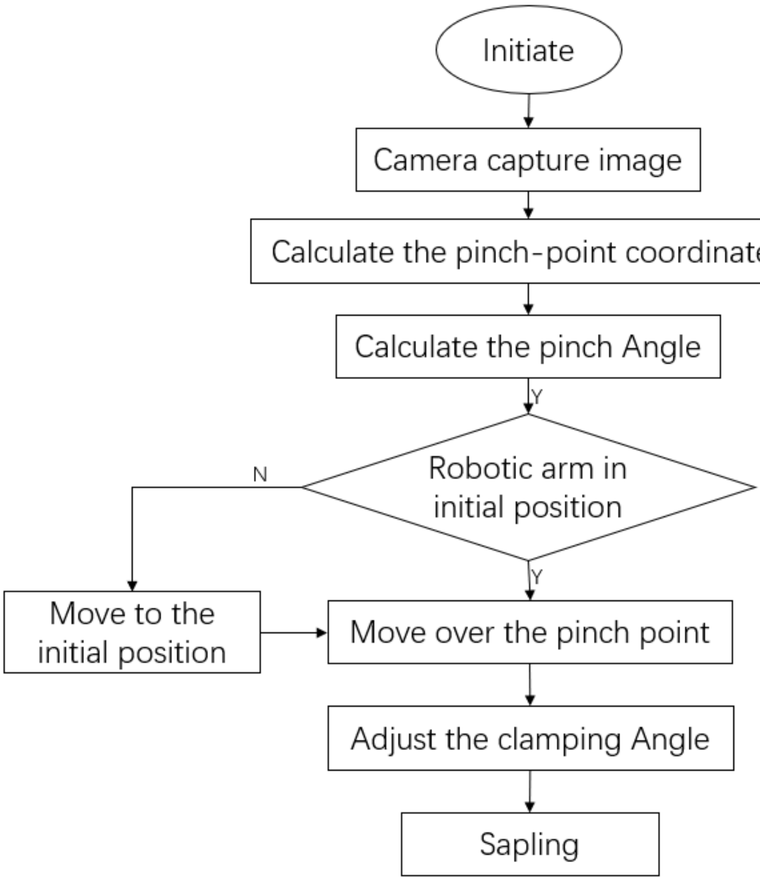

Figure 7: Plant saplings

4. Mechanical Control System

4.1. Condition of Test

The test was carried out on January 20, 2024 in Laboratory 803, North Building, School of Mechanical and Electrical Engineering, Wuhan University of Technology. During the test, seedlings were used as model trees and seedlings were sandy soil. The test prototype is shown in the figure below. Figure 8 is the prototype test diagram.

Figure 8: Prototype test drawing

4.2. Standard of Test

The equation for calculating the success rate of seedlings is as follows, where η is the survival rate of seedlings, N is the number of successful seedlings, and M is the total number of trees.

$$\eta = 100\% \times N/M \quad (6)$$

4.3. Results of Test

To verify the clamping effect, 50 simulated saplings were selected for the experiment. Of the 50 saplings, 37 were successfully planted, 3 failed to capture, 2 failed to transport, and 8 failed to identify. The failure of grasping is due to the tree slipping during the grasping by the mechanical claw, and the failure of transportation is due to the tree falling off before the sapling is transported to the claw point during the internal transportation of the machine. The failure of recognition is due to the K210 processing image, and the key point extraction is wrong. Table 1 shows the test results of the prototype.

Table 1: Table of results.

	Reasons for failure		
	Failure to grab	Sapling transport failed	Recognition failure
Number of saplings	3	2	8
Success/failure rate	6.0%	4.0%	16.0%

5. Conclusion

In this paper, a kind of seedling truck is designed for soil remediation and planting in saline-alkali land. Sensors and visual recognition technology are introduced to locate HSV space clamping points, and mechanical arm clamping is used to realize the combination of chemical and biological treatment. Compared with the treatment technology mentioned in the introduction, the repair time is shorter and the use range is wider.

For the tree saplings with developed root system, it is necessary to carry out multi-angle identification to find the center of mass and grasp the possible overlap. The next research will further improve the degree of freedom and visual recognition algorithm of the manipulator.

Acknowledgements

This work was financially supported by National innovation and entrepreneurship training program for college students.

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