Desert Guardian: Design of Seabuckthorn Automatic Tree Planting Robot

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Abstract: This paper focuses on the problem of desertification control in arid areas, The design, structure, working principle and advantages of the desert tree planting robot are described in detail. The situation of desertification in China is severe, and the cost of traditional tree planting methods is high and the survival rate is low. Therefore, the desert tree planting robot designed in this study uses astraPro depth camera positioning and multi-module cooperation. The integrated planting process can accurately complete the work of locating, digging holes, releasing seedlings, irrigation and backfilling. Increase efficiency and conserve resources. In this paper, the structure of the whole machine is introduced in detail, including the walking, storage, planting and irrigation backfilling devices. As well as the specific design and working mode of each component. Compared with other desert tree-planting robots, the design has high degree of intelligence and automation, and can effectively solve the existing problems. It is expected to provide an effective scheme for desertification control, promote desert ecological restoration, and help the sustainable development of arid areas. It is of great significance to improve the desert ecological environment.

Keywords: Desertification Control; Tree Planting Robot; Integrated Planting Process; Ecological Restoration

1. Introduction

Desertification is one of the major ecological and environmental problems in the world. China is a country with serious desertification [1]. There is a vast area of desertified land, especially in the northwest region, where land desertification has seriously restricted the local economic development and ecological balance. It brings many inconveniences and challenges to people's lives. Windbreak and sand fixation are very important to improve the ecological environment in these areas, and afforestation and grass planting are the main means. However, the traditional way of artificial tree planting is facing the dilemma of high cost and low survival rate of vegetation in the harsh desert environment [2,3]. With the continuous progress of science and technology, desert tree planting robots emerge as the times require and become a new hope to solve this problem. In recent years, scholars at home and abroad have carried out a lot of research in the field of tree planting machinery. However, the existing desert planters still have some problems, such as insufficient intelligence and automation [1]. Therefore, it is urgent to develop a tree planting robot which is efficient, intelligent and suitable for desert environment. The purpose of this study is to design a new type of desert tree planting robot, through depth camera positioning and integrated planting process. Reduce the cost of control, improve the survival rate of vegetation, and provide innovative solutions for desertification control in arid areas. So as to promote the restoration of desert ecology, realize the harmonious coexistence of man and nature, and help the arid areas to move towards the road of sustainable development [4].

2. Desertification Dilemma and Solution

The current situation of desertification in China is severe, especially in Northwest China. China is one of the countries with the most serious desertification in the world [5]. The area of desertified land is 2.57 million square kilometers, accounting for 26.81% of the total land area [3]; The area of desertified land is 1.68 million square kilometers, accounting for 17.58% of the total land area [6]. Especially in the northwest region of China, the phenomenon of land desertification is more

obvious, which has brought great trouble to the local development [2]. The effective means of windbreak and sand fixation is to plant trees and grass, but in the harsh environment, the labor cost of planting trees will be greatly increased [7]. In order to solve this problem, the desert tree planting robot has been designed. It can replace people's heavy manual labor in hard environments such as sandy land [8]. The desert tree planting robot has the characteristics of operation automation, and is convenient for human control in the working process. It can also adapt to the special geographical environment of sandy land and has broad application prospects [5,8].

3. Design of Seabuckthorn Automatic Planting Robot

The seabuckthorn automatic tree planting robot adopts depth camera positioning in design, The coordination between the single-degree-of-freedom drill bit system and the multi-module is realized. Specifically [9], the robot uses commonly used embedded devices as its control system, including the Arduino Mega2560 and the Raspberry Pi 4B. This design choice takes into account cost and volume considerations and is designed to improve productivity while saving labor costs.

In the working process, after the Astra Pro depth camera completes the positioning, at each point [10,11], the Raspberry Pi transmits a signal to the punching device to punch holes, and the saplings are transported to the tree pit through the conveyor belt. When the astraPro depth camera detects that the sapling has been planted, it passes the information to the Raspberry Pi, which communicates with the Arduino. The Arduino begins to control the chassis to move to the next location [12], while the backfilling device fills the previous tree pit, thus completing the sand fixation.

Compared with the existing desert planter, this design has obvious advantages. Scholars at home and abroad have carried out a lot of research on tree planting machinery. For example, the design of Zhao Yizhou is based on 51The car for planting trees around the lake designed by SCM, the drilling machine for planting trees in the desert designed by Zhang Yibo [2], and the machine designed by Meng Fanwei have a higher degree of automation. Cutting Seabuckthorn Planting Machine, Desert Tree Planting Robot Designed by Liu Yang and Manner JussiResearch on the existing tree planting machines in Sweden, etc [5]. However, these desert planters have low intelligence and automation, high requirements for operators, and lack of endurance. Single function, low capacity of saplings and the like. The seabuckthorn automatic tree planting robot adopts an automatically controlled seedling separating mechanism, a planting mechanism and an automatic path finding module [7]. It can realize efficient desert fully automatic unmanned planting, which is conducive to large-scale promotion of desertification control.

4. Structure and Working Principle of Desert Tree Planting Robot

4.1 Overall Structure

The hardware part of the desert tree planting robot system is mainly composed of a mechanical part and a control part [4], The structural design takes full account of the needs of the special desert environment.

The mechanical part comprises a walking device, a U-shaped vegetation storage device, a planting device and an irrigation backfilling device [8]. The walking device consists of a binocular camera and a crawler chassis, and the binocular camera can accurately acquire the position information of the marked points. With its unique structure, the tracked chassis has excellent trafficability in desert terrain. The storage device consists of a U-shaped tree box and a bottom conveyor belt, and the design of the U-shaped tree box not only can fully utilize the storage space, but also can keep that vegetation upright when the vegetation is transport on the conveyor belt, thereby being convenient for plan. The planting device consists of a vertical screw rod and a drill bit, and mainly undertakes the important task of digging a tree pit [6]. The irrigation backfill device consists of a water tank and a backfill plate, and the water tank is used for quantitatively irrigating the vegetation after the planting is finished; The backfill plate is used for backfilling the sand excavated when the tree pit is excavated.

4.2 How It Works

Desert tree planting robots use advanced depth

camera technology. The position difference of the object in different cameras is compared through the two cameras [5], Then the depth information of the object is calculated by using the triangulation principle, and the target detection and detection are realized through the depth information and the image features of the marked points [10], Tracking. And then position and navigating are realize based on that depth information and the target tracking result, the self position is determined and the move path is planned, Finally, it reaches the planting position of the reserved marking point.

When the robot reaches the designated position, all parts of the device work together. Firstly, a vertical screw rod is driven by a planting device through a stepping motor, and a drill bit is controlled by a direct current motor to complete the excavation of the tree pit. A conveyor belt at the bottom of the U-shaped tree box in the storage unit then transports the vegetation into the tree pit [12]. Then, the water tank is controlled by the DC water pump to realize the irrigation of the vegetation. Finally, the vehicle body drives the backfilling plate to complete the backfilling work of the tree pit [11]. And that integration of position search, pit digging, seedling release, irrigation and backfill in the process of vegetation planting is realized.

5. Design of Major Components

5.1 Planting Device

The planting device of the desert tree planting robot plays a key role after arriving at the designated location. The driving plate precisely controls the two stepping motors to rotate the lifting screw rod to realize the up and down movement of the excavating device and ensure the accuracy of the position [6]. At the same time, through MotorShield v2.0 to control the rotation of the drill bit, the two cooperate tacitly to complete the digging work efficiently.

$$H_a = (1-\beta)\frac{4r^3}{3\gamma^2} \quad (1)$$

Where, H_a is the actual pit depth, cm; β is the deviation coefficient between the actual condition and the ideal condition; r is the radius of the root of the sapling after it is wrapped with soil (which can be approximately regarded as a standard sphere), cm; γ is the radius of the tree pit, cm.

Calculate the deviation coefficient between the actual pit depth in the formula and the actual situation and the ideal situation, and calculate the deviation coefficient after the soil is wrapped on the root of the sapling [11]. Is closely related to the radius of the tree pit [10]. Take seabuckthorn seedlings as an example, their root system is relatively short, usually in the range of several centimeters to more than ten centimeters. Through the field test, the basic shaft diameter of the drill bit is 2. 5 cm, the drill bit diameter is 14 cm, and the drill bit length is 25 cm. According to the formula, the maximum depth of the system is 18 cm.

5.2 U-shape Vegetation Storage Device

The U-shaped vegetation storage device undertakes the important task of storing and transporting vegetation [10]. Its unique design can not only make full use of the storage space, but also can keep that vegetation in an upright state when the vegetation is transport on the conveyor belt, thereby greatly facilitating the plan process [9]. After the excavation of the tree pit is completed, the DC gear motor drives the conveyor belt at the bottom of the U-shaped tree box to accurately convey the sand-fixing vegetation to the tree pit. To ensure the smooth progress of planting work.

5.3 Irrigation Backfilling Device

The irrigation backfill device is mainly composed of a water tank and a backfill plate. After the vegetation is transported to the tree pit by the conveyor belt in the storage device [11], Arduino controls the DC pump to irrigate the vegetation quantitatively, which ensures the water needed for the growth of vegetation. Avoid the waste of water resources. The function of the backfill plate is to backfill the sand excavated by the drill bit when digging the tree pit [12]. When the water tank irrigates the vegetation quantitatively, the Raspberry Pi receives the irrigation end instruction and makes the chassis move forward by controlling the track. The backfill plate moves forward with the vehicle body to backfill the excavated sand and complete the last step of the whole planting process.

6. Conclusion

6.1 A Desert Tree Planting Robot is Designed to Solve the Problems of High Cost of Desertification Control and Low Survival Rate of Vegetation in Arid Areas

The emergence of desert tree planting robots has brought new solutions for desertification control in arid areas. The area of desertification in China is vast, especially in the northwest region, which has brought great trouble to the local development. The traditional way of afforestation and grass planting has high labor cost in hard environment. The design of desert tree planting robot aims to reduce the cost of management and improve the survival rate of vegetation.

Through depth camera positioning, multi-module cooperation and integrated planting process, Desert tree planting robots can efficiently complete tree planting tasks in desert areas. It can accurately find the planting location, dig holes, plant trees, irrigate and backfill, and reduce manual intervention. And that work efficiency is improved. At the same time, the robot can optimize the design according to the characteristics of the desert environment, such as digging tree pits with drill bits to reduce the backflow of sand. A U-shaped vegetation storage device is adopt to make full use of that space and ensure the vertical transportation of the vegetation; Through the quantitative irrigation device, water resources are saved while the water required for vegetation growth is ensured.

6.2 The Robot Realizes the Integrated Planting Process and Saves Water Resources through Depth Camera Positioning

The desert tree planting robot uses astraPro depth camera positioning to realize the cooperation of single-degree-of-freedom drill system and multi-module. Sand fixation protection and soil restoration are carried out on desert terrain in desert areas. The depth camera calculates the depth information of the object by comparing the position difference of the object in different cameras and using the triangulation principle and target detection and tracking are realized through depth information and image features of marked points, and then positioning and navigation are realized.

In the process of planting, after the robot reaches the designated position, all parts of the device work together. Complete the integrated process of locating, digging holes, releasing seedlings, irrigation and backfilling. For example, the planting device drives a vertical screw rod through a stepping motor, and a drill bit is controlled by a DC motor to complete the excavation of a tree pit; The storage device transports the vegetation into the tree pit; After the irrigation and backfilling device irrigates the vegetation quantitatively, the vehicle body drives the backfilling plate to complete the backfilling of the tree pit. This integrated planting process not only improves work efficiency, but also saves water resources. By adjusting the amount of irrigation water, the waste of water resources was avoided on the premise of ensuring the survival rate of sand-fixing vegetation.

In addition, it refers to the design of other desert tree planting robots, such as the "integrated desert vehicle for drilling and planting trees". The innovative drilling mechanism utilizes a motor to rotate a drill bit on a lead screw to ascend or descend through the transmission of a reduction gear set, When the drill bit does not reach the designated position, the rotation of the drill bit is due to the centrifugal force generated by the counterweight shaft. Nable that drill bit to be in a closed state so as to finish the drilling action in the desert, and when the drill bit reaches a specified position, limiting the shape of the counterweight shaft by the limiting re, The drill bit is gradually opened along with the downward rotation of the lead screw to finish the precise tree planting in the hole, and the planting efficiency is higher than that of the traditional tree planting vehicle. There are also intelligent desert seedling planting robots, which integrate seedling picking and seedling planting devices, reducing the cost of manpower and materials. It realizes the automation, programming and batch of the whole process of seedling planting. These designs provide reference and ideas for the development of desert tree planting robot.

To sum up, the design of desert tree planting robot provides an effective solution for desertification control in arid areas. Through the depth camera positioning and integrated planting process, it can not only complete the tree planting operation accurately and efficiently, but also realize the tree planting. But also can obviously improve the survival rate of the vegetation on the basis of reducing

the labor cost and the resource consumption, So as to gradually improve the ecological environment in desert areas. At the same time, it constantly refers to and integrates the design concepts and technical advantages of other advanced desert tree planting robots. With continuous optimization and upgrading, desert tree planting robots are expected to play a greater role in the field of desertification control in the future. It has become a key force to curb desert expansion and promote desert ecological restoration, and has contributed to the harmonious coexistence of man and nature. It will help the arid areas to move towards sustainable development and revitalize the desert. Add more green hope to the earth.

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