Intelligent Mowing Robot Design

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Abstract

This paper mainly introduces the design and implementation of intelligent mowing robots. Through the control of the sensor system and the single-chip microcomputer, a regular full-area coverage autonomous mowing is realized, and independent lawn trimming can be realized without installing cables and adding markers, and complicated path planning and image processing are avoided, and the grass is cut. High efficiency, no pollution.

Keywords

Mowing robot, obstacle avoidance, path planning, Arduino Meaga2560.

1. Introduction

Traditional lawn mowers have no way to autonomously mow, requiring manual operation and labor intensity. Automatic lawn mowers and mowing robots on the market can basically automatically mow. However, these mowers have a low level of intelligence and are not smart enough to identify the boundary. Pre-laying cables at the boundary is necessary to identify the boundary during the process of travel. This method of laying cables will bring a lot of users. The inconvenience. First of all, this method requires the cable to be embedded, and secondly, the cable must be powered. This not only increases the workload for the user, but also presents hidden dangers of insecurity. In addition, this type of mowing robot does not have precise navigation function, and it is difficult to complete the omission of covering mowing, so the mowing efficiency is not high enough.

The intelligent mowing robot of this design basically realizes the intelligent automation of lawn trimming work. No reference to automatic lawn mowing without cables or marking. Mainly adopts integrated navigation system1 and controller to achieve regular full-area coverage, autonomous mowing, high mowing efficiency, and certain obstacle avoidance and boundary recognition functions. No pollution, low noise, change the adverse effects of the traditional lawn mower application of gasoline engine as a driving force on the surrounding environment. There is also a safety device. The guarantor is in the danger zone that the mowing robot is in a dormant standby state and is suitable for pruning the home lawn.

2. Hardware System Design

The structure diagram of the intelligent mowing robot2 is shown in the figure below, using a three-wheeled cart design. This structure is relatively simple to control, only need to control the rear two drive wheels of the motor speed and rotation angle can accurately control the body movements, turning is more flexible, which is conducive to the mowing robot performing obstacle avoidance in real time during forward mowing. In addition, a mowing motor and a mowing blade are mounted on the lower side of the vehicle body, and a reduction gear is connected to the rotation shaft of the traveling wheel. The traveling drive motor is connected to the speed reducer through an encoder. In addition, an integrated navigation system is also provided on the output shaft between the two speed reducers. The integrated navigation system is connected with the main control module installed inside the body of the mowing robot. The main control module is also connected with the drive control module.

Put the intelligent mowing robot that has been calibrated at the starting position into the base station, start the power supply, let the robot start working, drive the motor to drive the two walking motors, and then drive the two walking wheels through the reducer to mow according to the planned route. When the robot encounters an obstacle, the ultrasonic sensor sends a probe signal to the front, and then the system will send a turn signal to the universal wheel to achieve the avoidance function. If a child or other creature is close to the body, the pyro electric sensor sends the collected signal to the sensor information processing module. After the signal is amplified and processed, the buzzer is triggered to remind the child or other creature to leave.

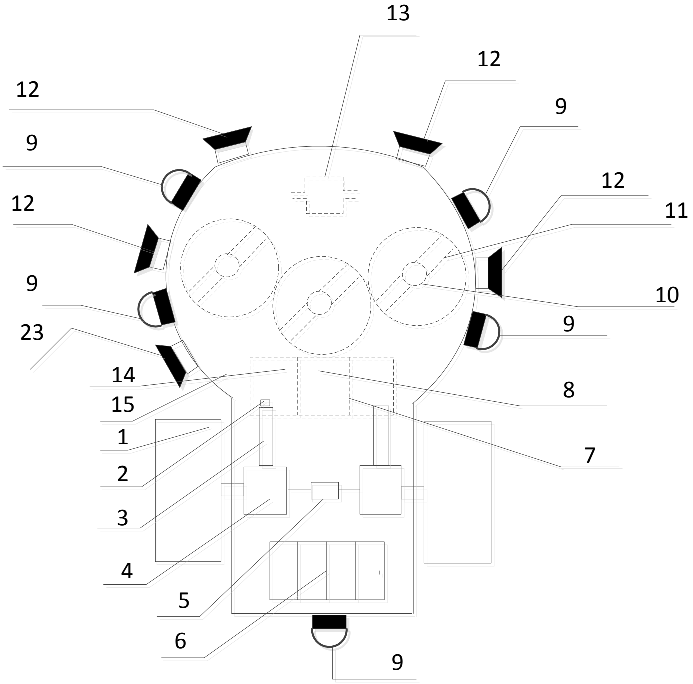
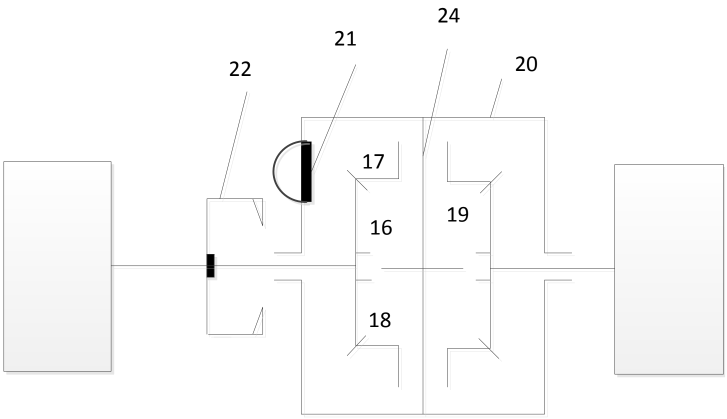


Fig 1. Mowing robot structure



1 Travel wheel 2 Encoder 3 Travel drive motor 4 Reducer 5 Integrated navigation system 6 Battery 7 Main control module 8 Drive control module 9 Pyro electric sensor 10 Mow motor 11 Mowing blade 12 Ultrasonic sensor 13 Swivel wheel 14 Sensor information processing module 15 Body 16 Bevel gear 17 Bevel gear 18 Bevel gear 19 Right bevel gear 20 Coupling seat 21 Speed difference sensor 22 Pointer 23 Warning 24 Rotating shaft.

Fig 2. Integrated Navigation System Structure

2.1 Control System

Although there are many kinds of control processors used in automatic mowers, they are mainly based on single-chip microcomputers and PCs. The single-chip microcomputer has a low price and a simple interface and is easy to program the interface. PCs are expensive and consume a lot of energy. Considering the requirements and cost-effectiveness of mowing robots, the main control system chose the Arduino Mega25603 microcontroller as the central processor. The Arduino Mega2560 microcontroller transmits data through a USB interface and a PC. It includes 54 digital inputs and outputs, 16 of which can be used as PWM outputs, 16 analog inputs, 4 UART interfaces, and a 16 MHz crystal oscillator. In addition, it can also be compatible with the expansion board designed by Arduino Uno.

2.2 Integrated Navigation System

The structure of the integrated navigation system is shown in Figure 2, including the left bevel gear and the right bevel gear, they are connected with the axis of the walking wheel. In addition, the left bevel gear and the right bevel gear also mesh with the upper bevel gear and the lower bevel gear perpendicular to the left bevel gear and the right bevel gear respectively. As can be seen from the figure, the self-rotating shafts of the upper bevel gear and the lower bevel gear are mounted on the spider seat, there are two speed difference sensors on the cross shaft seat, and there are pointers between the two speed difference sensors, the pointer is connected to the axis of the walking wheel.

2.3 Grassland Detection Device

The lawn detection device of the mowing robot is set inside the shell of the robot, so that the grass can be quickly detected and the missing grass area can be found. Non-grass areas can also be excluded, allowing mowing robots to stop running in non-grass areas, saving energy. An infrared emitting sensor4 and an infrared receiving sensor are installed in the housing, and the emitting surface of the infrared emitting sensor corresponds to the receiving surface of the infrared receiving sensor. The bottom of the housing is set with a rotating shaft, and the hanging shaft is set on the rotating shaft. One end of the hanging grass stall is set between the infrared transmitting sensor and the infrared receiving sensor, and the other end is set under the chassis. There is a spring between the haystack and the chassis. The back end of the haystack is also provided with a stop. The spring keeps the haystack at the stop position.

When the mowing robot walks into the grassland area, the grassing pole detects the grassland, receives resistance from the grassland, overcomes the pulling force of the spring, rotates counterclockwise around the rotation axis, and leaves the stopper. An effective light path can be formed between the infrared emitting sensor and the infrared receiving sensor, and the detection takes effect. When the mowing robot leaves the grass area, the spring will return the peg to its original position. When the mowing robot does not enter the grassland area, an effective light path cannot be formed between the infrared emission sensor and the infrared receiving sensor. If the detection fails, it can be determined that the current area is a non-grass area.

2.4 Sensor System

2.4.1 Ultrasonic Sensor

Ultrasonic sensors5 are non-contact detection and obstacle avoidance technologies that are not susceptible to light, smoke, and electromagnetic interference. Compared with infrared sensors, ultrasonic sensors have a longer range of action and higher reliability. Compared with the visual sensor, the operation is simpler, the processing speed is faster, and it is not limited by the light conditions.

As shown in the figure, four ultrasonic sensors are installed in the left, front and right directions, which is conducive to the robot to make correct obstacle avoidance. The installation of two ultrasonic sensors in the front position can reduce the distance measurement error to some extent. In order to avoid the mutual interference caused by the 4-channel ultrasonic sensors, cyclical transmission may be used.

Emitted from the transmitter by measuring ultrasonic waves, propagated through the propagation medium, and hit obstacles to return, the distance is calculated by the time t when the sensor receives the return signal. The principle formula can be expressed as $L=\frac{vt}{2}$ (L is the distance to be measured, v is the propagation speed of the ultrasonic wave in the medium).

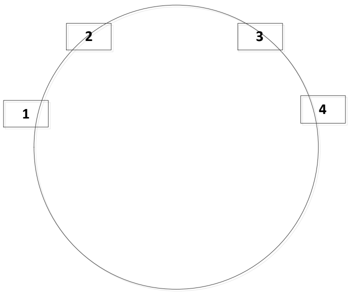


Fig 3. Ultrasonic layout

2.4.2 Tilt Switch

In the course of working, mowing robots sometimes make the body of the mower tilt or fall due to some accidents. Once the chassis of the car body is exposed to the outside, it is very likely to threaten the safety of people or animals because the chassis of the mowing robot is equipped with a highly operational mowing blade. Therefore, when the body of the mowing robot tilts to a certain angle, the tilt switch needs to give a signal to the microcontroller. The microcontroller then shuts down all motor runs based on this signal, and enters standby mode, where the operator manually turns on the unit.

2.4.3 Collision Switch

The collision switch6 can avoid obstacles and rapid-moving objects that cannot be detected by the ultrasonic sensor, and is a passive obstacle avoidance method. The principle of the collision switch is that after the mowing robot hits a mechanical spring structure in front of the object, Will short a contact. This can give a low-level signal to the microcontroller, notify the microcontroller encountered obstacles, mowing robots will implement the corresponding obstacle avoidance measures.

2.4.4 Rain Sensor

The rain sensor7 consists of a moisture sensitive resistor and a comparator. Under normal operating conditions, the resistance of the moisture sensitive resistor is approximately $1M\Omega$, which allows the comparator output to be high (positive voltage greater than negative voltage). If rain meets the humidity resistance, the resistance of the resistor will drop sharply to about $1K\Omega$, and the output of the comparator will be low. In this way, the microcontroller can be signaled to perform rain protection operations.

3. Software System Design

The software part of the intelligent mowing robot can be programmed with the single-chip microcomputer C language8, and realize the function of the mowing robot according to the actual control requirements. The use of modular programming, mainly including the speed control program, ultrasonic ranging program, inclination processing program. The software part try to use query instead of interrupt.

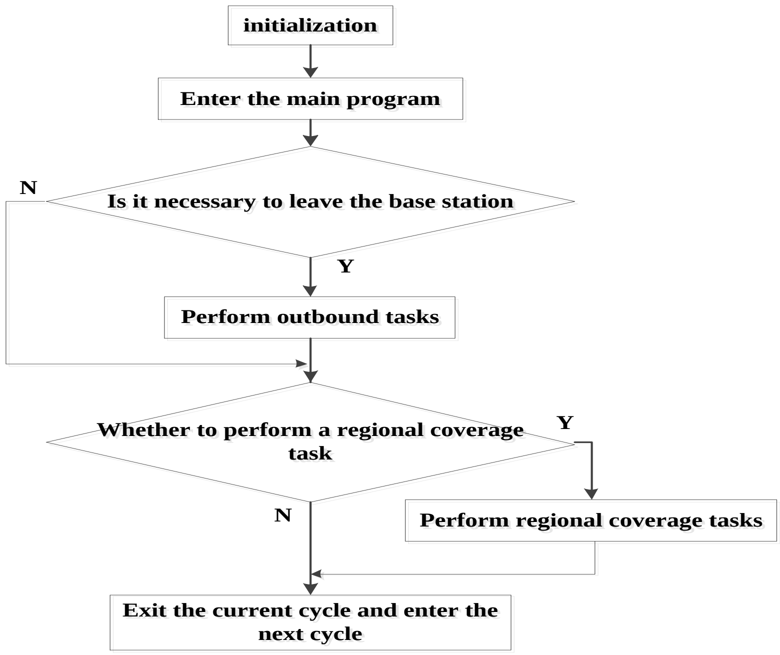


Fig 4. Main program

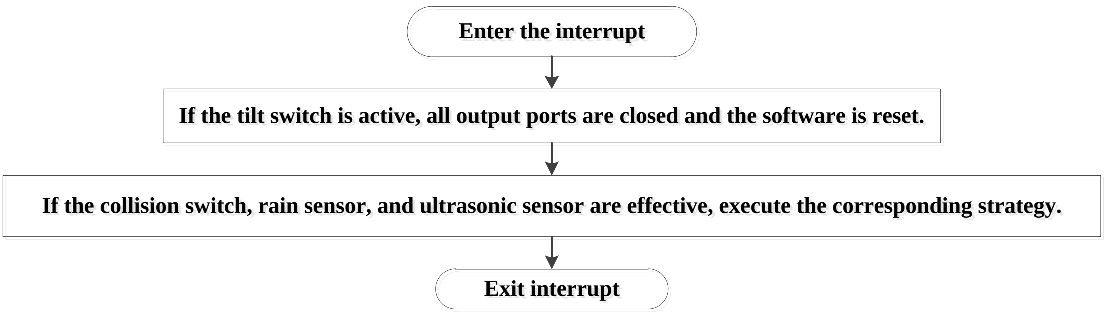


Fig 5. External Interrupt Service Routine

The main program mainly performs initialization and ordinary walking tasks of the mowing robot. In external interruptions, the signals of ultrasonic obstacle avoidance, collision avoidance switch, and inclination switch are sources of external interruptions and are used to respond to these emergency situations in real time.

3.1 Mowing Path Planning

For a fully automated mowing robot, efficient working methods are indispensable. Increasing the efficiency of mowing robots can be done in two ways. One is the upgrading of hardware. Including the upgrade of the chip, the optimization of the drive circuit, the improvement of the material of the mowing blade, etc. Another is the upgrade of software algorithms, including accurate and timely avoidance of obstacles, accurate work within the boundary line, as few as possible duplicate areas of work.

This system uses the base station as a reference for positioning and ultrasonic ranging. According to the mower internal information and external information to obtain the azimuth, and then get the specific coordinates of the mower. In each area, the mowing robot autonomously adopts a straight reciprocating method to cut grass, recognizes and turns after encountering the boundary, In this way, the entire region is covered by the mowing task. If a small obstacle appears in the forward direction of the robot, obstacle avoidance is performed to effectively avoid obstacles.

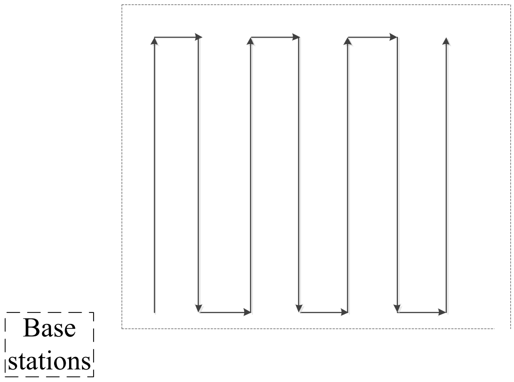


Fig 6. Path map

3.2 Coverage of the Entire Region to Achieve the Process Of Mowing

Before the mowing robot runs, according to the topography of the lawn, through the path planning9, the robot's mowing route is planned as a running program and solidified in the processor. The robot will complete the entire area covering the mowing task according to the preset procedure.

Place the mowing robot at the base station and calibrate the starting position, start the power supply, and let the robot start working, driving the motor, driving the two wheels through the deceleration of the reducer to follow the specified route. Due to the difference in speed between the two drive wheels during actual operation, the actual running trajectory of the vehicle body deviates from the planned route. So we connect the integrated navigation system to the output shaft of the two speed reducers. The integrated navigation system collects the deviation information of the walking trajectory in real time and feeds back to the drive motor to control the rotation speed of the left and right motors. In this way, the mowing robot is controlled to run on the planned route until it makes a 180-degree turn to the boundary, and the next round of mowing is performed. The identification of the boundary is mainly through the two encoders connected to the motor shaft to achieve the collection of the distance, and then the operating distance data is obtained by the single-chip microcomputer operation. When the distance between the data and the planned route is the same, a U-turn signal is issued. This repeated cycle of action, complete coverage of mowing the entire region.

If there are obstacles in the lawn, the ultrasonic sensor in operation acquires information and passes it to the information processing module. After being processed into the main control module, the avoidance of obstacle instructions is given to the drive motor, Drive the wheel to bypass obstacles.

4. Conclusion

The automatic mowing robot system draws on the characteristics of the mower system in foreign countries, focusing on the design of safety and reliability, and achieving better control. This design is helpful for the popularization and application of mowing robots from the perspective of economy, practicality and simplicity. With the update and improvement of electronic information technology, intelligent mowing robot systems will be more complete.

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