

## Design of low power triangle type stair cleaning machine

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**Keywords:** Low power consumption; triangle wheel; stair; Sweeping machine

**Abstract.** The traditional way of manual cleaning stairs, not environmental protection, cleaning efficiency and low, cleaning workers time and labor, in order to solve this problem, the design of a low power MSP430 series single chip staircase. The cleaning machine realizes the combination of the triangular roller and the ordinary wheel to realize the plane movement of the cleaning machine and the down stairs sweeping action. Multi sensors are used to collect the information of road surface, drive the stepper motor module, realize the function of location identification, automatic obstacle avoidance and so on. Through the steering gear to adjust the angle of the sweeping brush, so as to achieve the purpose of cleaning the stairs. The experimental results show that the cleaning machine can realize intelligent path identification, obstacle avoidance, downstairs and cleaning function, stable and reliable operation, with small structure, light weight, low cost, etc., has a certain practical value.

### Introduction

With the development of society, more and more intelligent systems are beginning to take the place of human labor, and they are becoming more and more automated and intelligent [1]. The traditional way of manual cleaning is not only environmental protection, but also low cleaning efficiency. In such a special public environment, it is necessary to replace the traditional manual labor with high efficiency of cleaning tools, a large area of one-time cleaning and easy operation. Takahisa Kakudou et al. Proposed a kind of box climbing robot, which is a combination of climbing and cleaning, and uses the flip up and down way of the [2,3]. He Lianyun [1,4] proposes the use of a parallelogram deformation characteristics achieve downstairs cleaning function of robot, its control core is STC89C51 SCM, response speed and information processing ability is insufficient. Therefore, this paper designed a low-power triangular wheeled stairs cleaning machine, the triangle roller and ordinary round combination, to achieve cleaner horizontal movement and downstairs, a brush cleaning mechanism for cleaning function of stairs on the ground. The cleaning machine with low power consumption MSP430 series processor, sensor detection with combination stair information, identify the location and obstacle avoidance functions, by controlling the stepper motor and steering action, so as to control the cleaning machine for walking, and a brush cleaning action.

## 1 Design of the Overall scheme of the low power triangle stair sweeper

### 1.1 Working principle of the cleaning machine

The working principle of the cleaning machine mainly includes: cleaning operation, garbage disposal, operation protection, etc.

- Cleaning operation mode: The sweeping machine adopts the combination of the triangle wheel and the common wheel, from top to bottom of the stairs slowly from one section to the next section of the operation steps, cleaning machine cleaning brush will run back together with the cleaning machine, and on the stairs under the action of gravity for cleaning. When the cleaning machine runs to the junction of the stairs and floor, identify the current location signal through the sensor, then control the stepper motor to make the cleaning machine turned 90 degrees, moving to the next section of stairs to work, always repeat the above process until the cleaning the stairs. The working track of the sweeper is shown in figure 1.

- Garbage disposal: The size of the cleaning machine is small, the garbage collection will



motor is more reasonable, so that the motor can make the cleaning machine has a simple and clear visual effect on the space structure, and the motor mounting bracket is shown in figure 6. The brush is used to clean the rubbish on the stairs. It is made of acrylic board, as shown in figure7. Cleaning brush installation platform as shown in Figure 8, the component is mainly used to clean the brush connection, but also part of the system circuit installation platform. UG software design with the chassis effect diagram shown in figure 9. The mechanical structure of the chassis is shown in figure 10.

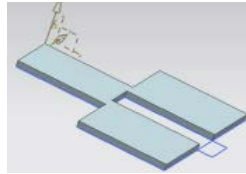


Fig. 3 Circuit board of cleaning machine

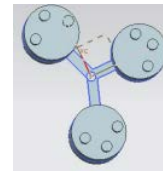


Fig. 4 Triangle wheel of cleaning machine

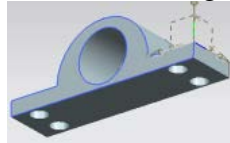


Fig.5 Cleaner assembly bearing

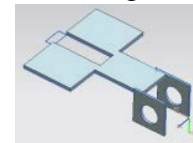


Fig.6 Cleaning machine motor mounting frame



Fig.7 Cleaning brush

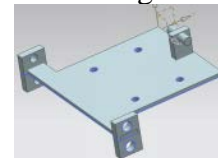


Fig.8 Cleaning brush installation platform

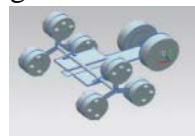


Fig. 9 UG renderings



Fig. 10 Chassis physical map

### 3 Design of the hardware circuit of the low power triangle wheel cleaning machine

#### 3.1 sensor module

The sensors used in this paper are mainly photoelectric switch and tilt sensor. The photoelectric switch is infrared sensor, mainly using the principle of light reflection, the switch head has a pair of infrared receiving tubes and tubes, when an object is within the sensing range of the probe, the launch tube emits light reflected by the object is received by the receiving tube, thereby changing the state of the circuit. The tilt sensor is the use of conductive copper ball in the trigger circuit, when the sensor is tilted in the conductive bead in the cylinder in its internal rolling, so as to realize the change of angle judgment. In order to solve the problem that the output level of the sensor can not be read directly by the processor, the level conversion module is added in the system to realize the handshake between the sensor and the processor. The sensor is connected with the processor, as shown in figure 11.

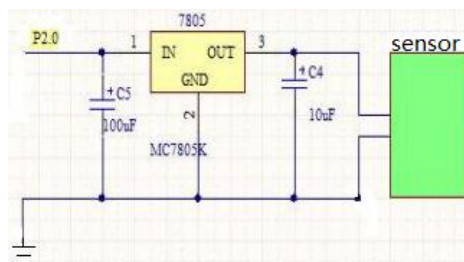


Fig.11 Sensor and MSP430F149 connection schematic

#### 3.2 Infrared sensor module

In order to minimize the damage caused by the cleaning machine, the cleaning machine is equipped with an infrared sensor module. Infrared sensor module and MSP430F149 connection

schematic, as shown in figure 12. When someone is in the probe sensing range, the probe inside the PNP three tube disconnection makes the circuit is disconnected, the microcontroller P1.0 pin is low, so that the stepper motor control signal failure. Make the machine stop running, to protect themselves.

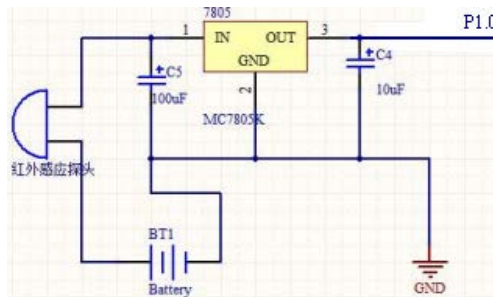


Fig. 12 Schematic of infrared sensor module and MSP430F149 connection

### 3.3 Stepping motor and driving module

Cleaning machine is used for beauty Beng high torque 12V six sub line two stepper motor drive module, motor drive using L298N. Stepper motor drive schematic, as shown in figure 13.

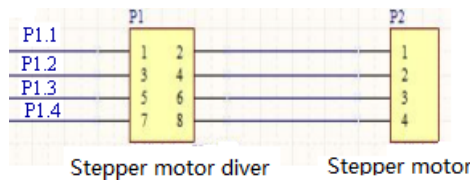


Fig. 13 Schematic diagram of stepper motor drive

### 3.4 MG996R steering gear drive module

The steering gear drive module is mainly used to control the steering gear, it uses the specific coding chip to change the resistance value of the circuit to realize the precise control of the steering angle. MG996R type steering gear is a kind of 180 degree rotation angle steering gear, which has the characteristics of accurate angle and low noise. In fact, as shown in figure 14. The steering gear control, there are many methods, such as using SCM IO port output PWM to control steering, can also use the servo drive plate is connected with the 10K variable resistor, resistor can be adjusted by rotating the rotation angle of the steering gear. In this paper, PWM wave steering control, steering control circuit schematic diagram, as shown in figure 15.



Fig. 14 MG996R type steering gear

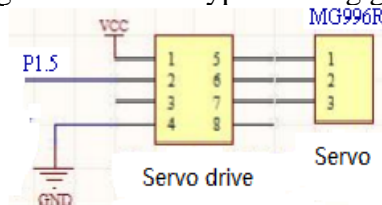


Fig. 15 Schematic diagram of steering gear control circuit

## 4 Design of the software of the low power triangle wheel cleaning machine

Cleaning procedures include: main program, interrupt program, stepper motor driver, steering gear control program.

### 4.1 Design of the main program

The main flow chart of the cleaning system is shown in figure 16.

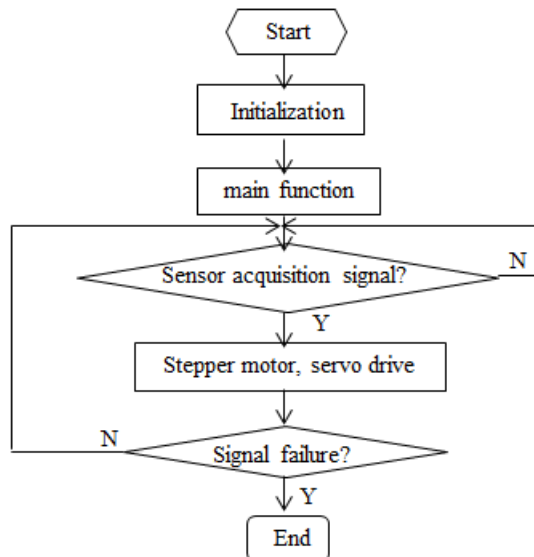


Fig. 16 The main program of the flow chart

#### 4.2 Design of Stepper motor driver

The PWM control step motor is adopted in the cleaning machine control system. PWM wave control stepper motor timing diagram, as shown in figure 17. The speed control of stepping motor can be changed by changing the duty cycle of PWM wave. Cleaning machine for motor using single step control method, using IO simulation PWM wave of motor control. Motor control flow chart, as shown in figure 18.

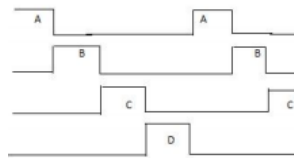


Fig. 17 The diagram of PWM wave control of stepper motor timing

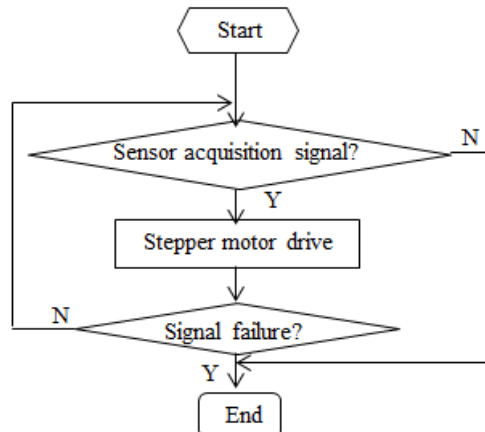


Fig. 18 Flow chart of stepping motor control

#### 4.3 Design of Servo control program

MG996R servo control structure, as shown in figure 19.

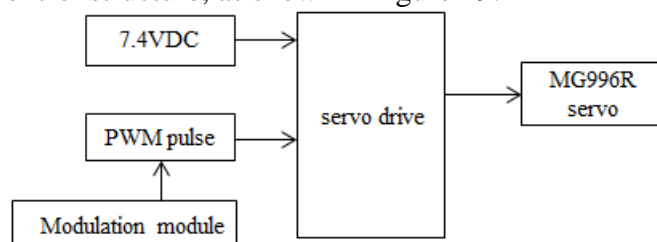


Fig. 19 The structure of steering gear control  
Steering control flow chart, as shown in figure 20.

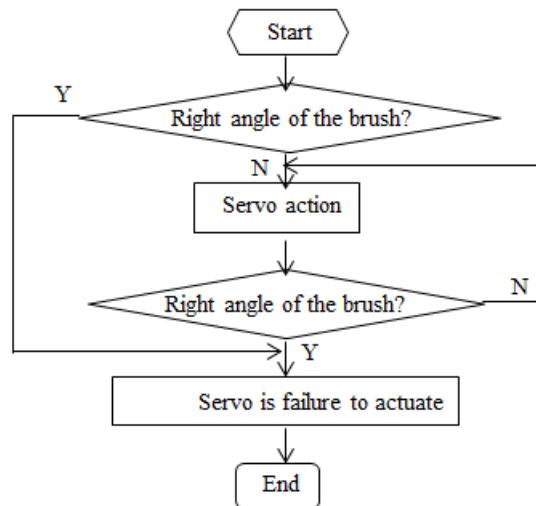


Fig. 20 Flow chart of steering gear control

## Conclusion

Low power wheeled stair sweeper with delta MSP430 series single-chip microcomputer as control core, integrated photoelectric sensor module, stepper motor and servo module, and the corresponding software program under the control of the stairs collection information, the cleaning machine cleaning work and walk from top to bottom. The experimental results show that the cleaning function of different stair height, with the speed of 0.3m/s walking, and location identification, automatic obstacle avoidance function, low power consumption, small volume, light weight, stable and reliable operation, can reduce the staircase corridor cleaning labor intensity and improve labor efficiency, reduce the cost, provides a simple and convenient cleaning appliance for environmental protection workers, has a certain application value.

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