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DESIGN OF A TYPE OF CLEANING ROBOT WITH ULTRASONIC

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ABSTRACT

A cleaning robot based on the ultrasonic principle is designed. With the single chip microcomputer AT89C52 and ultrasonic sensors, the robot can achieve the function of intelligent obstacle avoidance, automatic control and automatic sweeping. In the cleaning robot, a rotating cylindrical brush is used in front of the robot and it sweeps garbages into the dustbin in the process of movement, and a moist mop is used at the back of the robot, and it can sweep the ground when the robot is working.

Keywords: *Cleaning Robot, Ultrasonic sensors, obstacle avoidance, AT89C52*

1. INTRODUCTION

The cleaning robot belongs to a type of mobile robot in family environment and its development promotes the development of home service robot industry [1]-[2]. But the moving way of robots are different [3]-[4], and this issue has become a research focus in recent years [5]-[6].The typical representatives of high-level robots are RC3000, Roomba, DC06, trilobites, VC-RP30W, etc [7]-[8]. The way of walking of RC3000 is random; Roomba and DC06 clean room with helix manner and they can avoid obstacles well; the cleaning way of the RC3000 is random coverage mode; the trilobites can free shuttle to clean and design their own best routes[9-11].

Robotics research is mainly to solve the problems of where the robots are, where to go and how to go. The key is the navigation problem [12-14]. Many researchers divide the navigation into four parts of map building, localization, and path planning and obstacle avoidance.In many studies, some scholars achieve the positioning by using different sensors and special operations. The common sensors are ultrasonic sensor and Sonar sensors; the commonly used algorithms are Global Localization, GPS positioning method and Monte Carlo positioning method [15-20].Path planning still is the research focus of experts and scholars, some scholars have enhanced the path planning studies from two-dimensional plane to three-dimensional space, from single robot path planning to multi-robot walking [21-23].

Cleaning robot is a type of mechanical and electrical products for sweeping and dusting. It is superior to an ordinary vacuum because it is more convenient to use and it can save more time when it works. The whole cleaning process doesn't need a person to control and it reduces the burden on the operation. The noise is smaller than the general vacuum cleaner when it is working. It can purify the air; adsorb harmful substances in the air with activated carbon in it. Its dust purification rate can reach 96%, and the cleaning efficiency can reach 99%. Its structure is compact and lightweight, but it can clean up some special space. If you install the radio on it, you can also listen to music in the process of charging and sweeping. In short, cleaning robot is combined with mobile robotics technology and dust sweeping project and it is intelligent and convenient. So it is an environmentally friendly, healthy, intelligent service robot with a good prospect and a wide range of market demand [24-25].

Therefore, the development of autonomous intelligent cleaning robot not only has a challenge on the research, but also has broad market prospects; it is the integration of key technologies of modern sensors and robotics.

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2. GENERAL DESIGN

Figure1 shows the total system block diagram. AT89C52 microcontroller is used as control unit. General transmitting tubes and receivers are used in the ultrasonic sensor. The ultrasonic sensor detects the surrounding environment, and then transmits signals to the single chip microcomputer system.

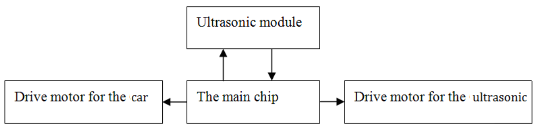

Figure1 The Total System Block Diagram

3. DESIGN OF STEERING UNIT

The ultrasonic sensors are used in obstacle avoidance. The signals emitted by the ultrasonic sensors have certain space launch angles, and the special ultrasonic module converted the distance into high level time, so that the single chip microcomputer only need to calculate high level time to be able to judge the distance of obstacles, and the measuring is very easy. Because the signals are ribbon, it can determine the obstacle within a certain range.

4. DESIGN OF STEERING UNIT

The rear-wheel drive is adopted in the steering unit, the front wheel is the universal wheels and it can move in longitudinal forward rotation and rotary reversing in the horizontal plane. It has simple structure, ease processing, reasonable software design, and the steering precision can meet the steering requirements but more economic. Figure2 shows the structure of the universal wheel.

5. DESIGN OF OBSTACLE AVOIDANCE SCHEME

The intelligent car avoids obstacles by using the fuzzy control, and in order to reduce production costs and maintain the beautiful looks of the car, we use stepper motor drive ultrasonic module to rotational scan. Through debugging and calculating ultrasonic dispersion angle, we use five points canning method, the five points are front, left front, left, right front, right that respectively denoted by L, ML, M, MR, and R. During the scanning, if it judge the value of "1", which indicates that there is obstacle, and the car will stop advancing and sweeping, it rotates to avoid obstacles. If the value is "0", which indicates there is no obstacle and the car will move on and sweep the floor. Figure3 shows the possible obstacles when the car moves. Considering the car speed and the distance to the obstacle, in order to avoid hitting obstacles when turning, the car should retire, and then rotate when it detects an obstacle, and then detect obstacles and continue to adjust until around obstacles.

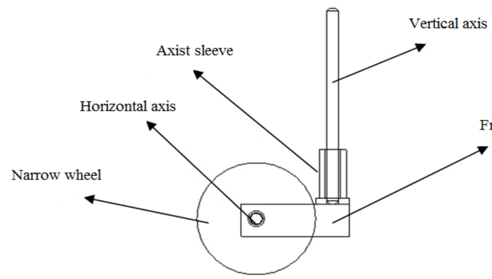

Figure2 The Structure Of The Universal Wheel

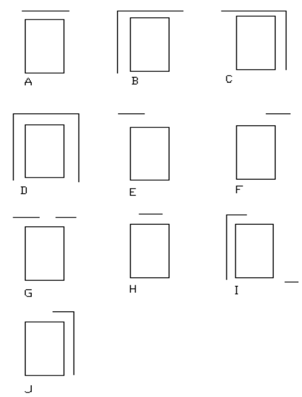

Figure3The Possible Obstacles Of Car Movement

Figure4 shows the scanning distance of the intelligent car, it is by semi-circular distribution. When it is walking, the car main scans three points: middle (M), middle right (MR), middle left (ML). The safe distance is 25cm, if it is smaller than this value, the car will avoid obstacles based on fuzzy control programs. When it discovers the obstacles, the ultrasound will scan left side and right side, and the safety distance between the left side and the right side is 20cm.

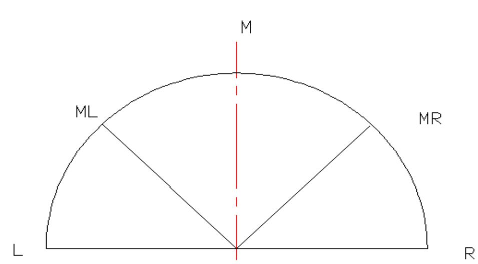

Figure4 Ultrasound Scan Points

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The ultrasonic emitted by ultrasonic sensor is diffraction, and the expansion angle is calculated as follows.

$$\theta=\arcsin 1.12\times\lambda/D\approx 70\lambda/D \quad (1)$$

In which, the ultrasonic wavelength $\lambda=s/f$, the velocity of sound s=340m/s, the ultrasonic module frequency f=40KHz, r is the radius of the ultrasonic radiating, so$\theta=37°$.

The main technical parameters of stepper motor 28BYJ48 are shown as follows, the reduction ratio 1:64, the step angle $\alpha=0.088°$, the rear wheel diameter of the robot car R=77mm, wheel circumference L=241.78 mm. The small car angle change and line distance are proportional, and the formula is shown as follows.

$$\alpha/360°=1/L \quad (2)$$

When the speed linear s1 of the stepper motor is 20mm/s, the corresponding angular velocity α is 30°/s, and there are other parameters, the stepper motor rotate is 30° every second, the microcontroller needs to send 341 pulses, the frequency is 0.0029. The ultrasonic rotary stepper motor linear speed is 50mm/s, corresponding angular velocity is 75°/s, the stepper motor rotate is 75° in unit time, microcontroller needs to send 853 pulses, the frequency is 0.0012.

The rear wheels of the cleaning robot car are driving wheels, the center distance of rear wheels is 125mm, and the rotating circle of circumference is 392.5mm. If the car turns 90°, the walking distance of every wheel is 98.125mm, the number of pulses required is 1022.

6. SOFTWARE DESIGN

When the intelligent car is powered, the microcontroller will drive a stepper motor to move forward and the ultrasonic sensors scan for obstacle avoidance. The program design of the car includes the following sections, the main program, subprogram of front detection and action, subprogram of obstacle avoidance action 1 (action for front obstacle only), subprogram of obstacle avoidance action 2 (action for left front obstacle only), subprogram of obstacle avoidance action 3 (action for right front obstacle only), subprogram of obstacle avoidance action 4 (action for left, right, front obstacle), detection subprograms map of left 45°, detection subprograms map of right 45°, and ultrasonic sensors detect subprograms. Figure5 shows the main program block diagram.

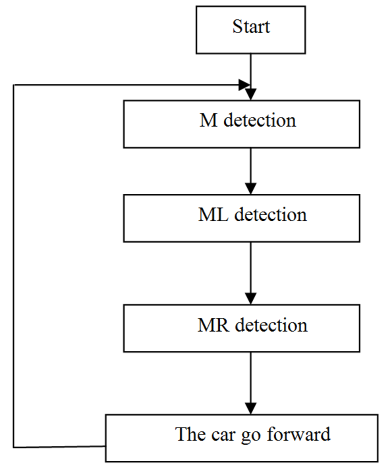

Figure5 Main Program Block Diagram

7. CONCLUSION

A robot used for household cleaning is designed. The function of the intelligent robot includes obstacle avoidance, sweeping and mopping the floor. Figure6 shows the whole system structure. AT89C52 is used as control unit of the robot, and fuzzy control is used for obstacle avoidance. With the ultrasonic sensor and stepper motor, the robot can be automatic control and automatic sweeping, and it can avoid most of the obstacles in the local area. The using of spiral brush is particularly effective to deal with some small pieces of garbage, such as paper clips, paper and soil block. The cotton is used in the robot when sweeping the floor, since it has a good absorption capacity, and it can absorb most of the dust and solve the shortcomings of the spiral brush when the robot is working.

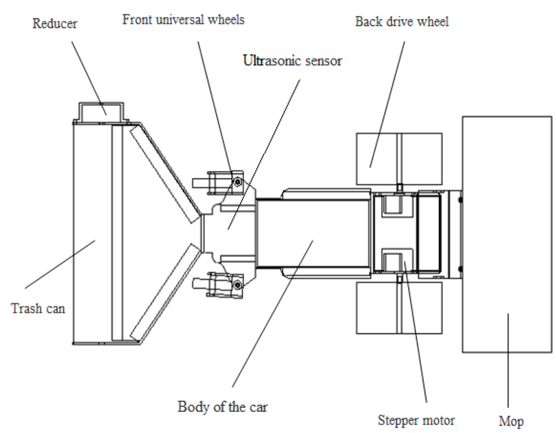

Figure6 The Whole System Structure.

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