Research of An Automatic Mopping Assistant Robot

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Abstract. This paper proposes an automatic mopping assistant robot, it has functions of auto-following, providing clean water, storing up sewage and washing mops. Firstly, to get the goal of auto-following, the robot has 1 ultrasonic module and 2 infrared modules that are connected with 1 Arduino motor driver that on 1 Arduino UNO board, the former for distance, the latter for direction, they cooperate to give robot ability of following people and keeping a safe distance from users. Secondly, in terms of the mechanical structure, the robot is designed with 3 water sinks that are interconnected, which can provide water for cleaning mops at any time; finally, There is a cross-shaped brush on bottom of the cleaning sink, so when an electric mop is put on it and turned on, the mop will be cleaned. The experimental results show that the robot achieves the expected function and runs well.

1. Introduction
Mopping is an integral part of household cleaning, and a clean floor gives people a comfortable feeling. However, according to research, most families are using traditional mops, and they often encounter the following problems [1]:

1. frequent bending down when mopping the floor,
2. laborious swinging of arms,
3. reusing a bucket of dirty water,
4. running back and forth between the tap and the mopping destination

These problems lead to people being tired, wasting water [2] and inefficient mopping, people need a device to solve the problems. Although there are a lot of floor mopping robots on the market, there are some places that they can't clean, such as the bottom of the table and some complicated places. In addition, the work efficiency of these robots is far lower than what people do, so we designed an assistant robot (Figure 1) to cooperate with the user to reduce the workload and clean most areas at the same time.
2. Design of Auto-following Function

2.1. Circuit Design
To get the goal of auto-following, we designed circuits specifically for the robots (Figure 2) First of all, the Arduino UNO circuit board is computationally powerful enough to perform the functions mentioned above. And it’s relatively cheaper, so it’s one of the best options for making this robot. Secondly, the circuit system is powered by a 7.4 to 9 volts of battery. For the drive part, there are 4 bidirectional DC motors respectively connected to the M1 to M4 pins on the Arduino motor driver. For the judgment part, 1 ultrasound module and 2 infrared modules are connected to the motor drive board, and the motor drive board provides 5V working voltage, the Echo pin and Trig pin of the ultrasound module are connected to the A0 pin and the A1 pin of the motor drive board, the OUT pin of the right infrared module is connected to the A3 pin, and the OUT pin of the left one is connected to the A4 pin.

2.2. Control Method
For distance, the distance between the robot and the user is measured using the ultrasound module [3]. The critical distance is 300 mm. The robot moves forward when the distance is greater than the critical value, remains in place when the distance is equal to the critical value, and moves backward when the distance is less than the critical value (Table 1).

For direction, the robot has two infrared modules on its head, which are distributed 120 degrees apart on both sides of the head (Figure 3). When the user is on the left side of the robot, the detection signal emitted by the infrared module on the left side will be reflected and absorbed by it again. Therefore, the infrared module on the left side has a signal input but not on the right side. At this time, the wheel of the robot rotates differently in speed, which makes it achieve the target of present turn [4]. For other steering conditions see the table (Table 2).
Figure 2. Wiring structure of control section.

Table 1. Motion State Corresponding to Different Distances Measured by The Ultrasound Module.

| Distance (mm) | <300 | ≥300 | >300 |
|---------------|------|------|------|
| Motion state  | Back | Remain | Forward |

Figure 3. Control principle of robot.

Table 2. Turning Corresponding to Different Signal States of Infrared Module.

| Signal reception | Left only | Right only | Both received | Both not |
|------------------|-----------|------------|--------------|----------|
| Motion state     | Turn left | Turn right | Remain       | Remain   |

2.3. stability analysis

In order to verify the stability of the robot, we analyzed the operation of the robot in the following two situations
Let’s first verify the robot’s operation while the user is parked in place. We connect the robot to the computer via a data line, then open the switch of the robot and the robot starts to run. At this time, let a user stand in front of the robot and hold still. After doing the above steps, open the Arduino IDE on the computer to collect the distance measured by the robot through the serial port, and then import the data measured by Arduino into Excel through Python. Excel generates a graph (Figure 4) showing that the robot keeps a strict distance of 300mm from the user within 0s to 20s. This result conforms to the situation mentioned above, that is, the stability of the robot meets the requirements.

Next, verify the motion performance of the robot. The user holds a mop, stands in front of the robot for a period of time, then turns left and walks forward 1m. The computer collects the data measured by the robot in this process, and the method of data collection and analysis is the same as the previous step. We’ve got a chart (Figure 5). The details of the process have been shown in the chart. The chart suggests that the robot's sensors are very sensitive, so that the robot can catch the user's movement and follow him. In addition, it should be noted that the reason why the graphic line in the middle part reduced to 0 is that the experimental environment is empty, and the ultrasonic module will not receive the reflected wave when the distance is greater than 2.5m.

![Figure 4](chart1.png)

**Figure 4.** A chart to verify robot’s operation while the user is parked in place

![Figure 5](chart2.png)

**Figure 5.** A chart to verify the motion performance of the robot
3. Design of Water Source Utilization Device

3.1. Water Storage Sink
In order to improve the efficiency of mopping and reduce the times of washing mops back and forth, the robot has a water storage bin, which can hold 5L water each time. A water pump is installed at the bottom of the barrel, which can send clean water into the cleaning tank. In addition, we have also conducted parameter studies with the market mowing robots to demonstrate that our robots have advantages in capacity of battery and water (Table 3).

3.2. Cleaning Sink
A cross-shaped brush is installed in the sink (Figure 6). When the electric mop contacts and rotates with it, the hair and soil on the mop will be cleaned. The notch also adopts chamfering design, which improves the alignment and makes the mop enter the cleaning slot more smoothly.

3.3. Sewage bin
The bin is designed to collect sewage, and it is oval in shape, which can ensure that its volume is equal to the volume of clean water in the clean water tank. In addition, when the sewage is discharged from the cleaning tank into the sewage tank, the large opening can prevent it from splashing around.

| Robot      | Waterloading capacity(ml) | Battery capacity(mAh) |
|------------|---------------------------|-----------------------|
| ISWEEP-006 | 180                       | 2000                  |
| KRV210     | 150                       | 2000                  |
| KOKO       | 200                       | 4000                  |
| I5-Young   | 450                       | 2600                  |
| Ours       | 5000                      | 8000                  |

Figure 6. The sewage bin.

4. Conclusion
In order to solve the problems of mopping, this paper presents an automatic mopping assistant robot, it has functions of auto-following, providing clean water, storing up sewage and washing mops. The experimental results show that the robot achieves the expected function and runs well. In addition, the cost of this robot is lower than that of products on the market, so it is more acceptable to users.

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