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Intelligent Vacuum Cleaner Mobile Robot

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ABSTRACT: *The rapid growth of advanced robots has given researchers unprecedented opportunities to explore and discover new fields of research where robots can be used to assist humans in their daily life. Mobile robots are coming into increased use in a wide range of applications such as industries, medical and domestic machines. This paper presents an intelligent vacuum cleaner mobile robot which has been designed, fabricated and tested. The main target is to design a robot that can detect objects and avoid them while moving and cleaning. The robot is equipped with some sensors in order to have the ability to navigate its way without any collision with any obstacle that may occur in the place to be cleaned.*

KEYWORDS: Mobile robots, Vacuum Cleaner, Obstacle avoidance, Navigations

1. Introduction

Cleanliness is one of the important aspects in human life. Our prophet S.A.W. also said that the cleanliness is part of our faith. Because of the importance, many kind of cleaning mechanisms are invented to ease the human daily chores. One of them is vacuum cleaner. Vacuum cleaner, as generally known, is used to clean dust and small rubbish by sucking it into the waste bag. Nowadays, almost every house in the urban area has a vacuum cleaner and commonly, this vacuum cleaner is operated by man himself which will require energy and time consumption. In this new millennium, technology has been developing rapidly and every day, new invention appeared in order to make human life easier. The vacuum cleaner itself is in evolution to make it intelligent and move by itself without man to operate it. The brand like Electrolux and Minolta had already produced their own intelligent and autonomous vacuum cleaner with their own different features. To make the vacuum cleaner move by itself, we have to fix a system which could drive the vacuum to move. The best way is by implementing the mobile robot system. By integrating the vacuum cleaner with mobile robot, we will have our own intelligent vacuum cleaner mobile robot which can move by itself intelligently while we are reading our daily newspaper. Besides having our smart vacuum moving by itself, we also want our vacuum cleaner to be smart enough to differentiate the capacity of the mess so that it can use lower energy for not-so-dirty mess and more energy for heavy mess. By this, we will not only save the human energy and time but saving the electricity and cost for the bill too. This will avoid waste of energy and money while the mess will be cleaned as we wish. The robot not only moving by itself, and smart to differentiate the mess, it is also required to clean the dirt properly and in various floor conditions. Sometimes we got carpet, or mat on the floor, so our vacuum cleaner should have a capability to vary its height so that the distance between the sucking mechanism and the dirt will always be in the right position. This will benefit in cleaning the mess properly and saving the energy. By these three important aspects, what else we want our vacuum cleaner to be? We will have a smart, energy-saving, cost-saving, environment-friendly and human friendly vacuum cleaner we ever had.

2. System Design

The system has been divided into two main parts; hardware and software. The hardware part includes the mechanical and electronic system, while the software part is dealing with the programming for the motion control and robot navigation.

2.1 Robot Design

The robot has the differential steering configuration for the mobility. It used two rear wheels and one caster wheel in the front. The base of the robot is made up by a perspecs plate which is divided into upper and lower base. The upper base hold the motors and rear wheels while the lower base placed a battery, caster wheel, circuit and the handy vacuum. The sketch of the exploded view of the robot is shown in Figure 1. The base of the robot has been design such that the size and the weight are reduced to the most compact and lightest shape. This will let the robot operate in the most efficient way. The robot is about 33 cm wide, 15 cm height and 40 cm length including the vacuum cleaner which is placed on the front center of the base. The perspective of the base is shown in Figure 2

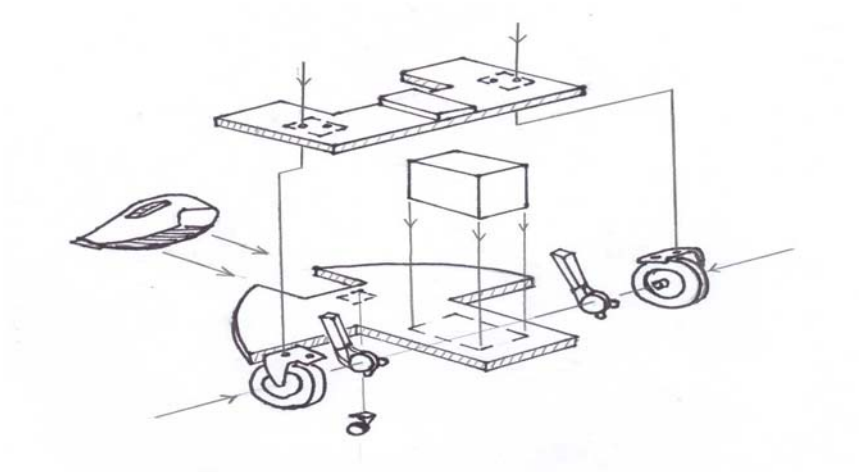

Figure 1. *Exploded view of the robot*

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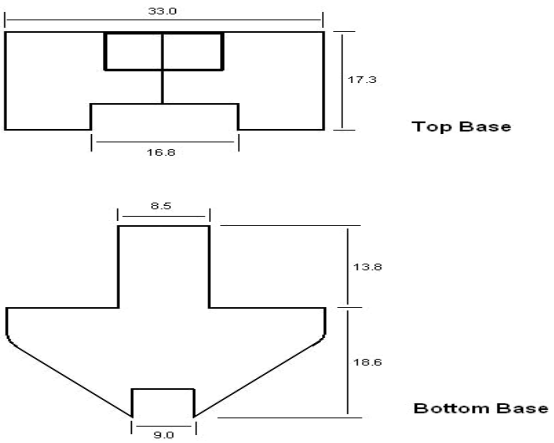

Figure 2. *Perspective of the base*

2.2 Mobility configuration of the wheel

For smaller space requirement when moving and simplicity, the robot used the differential steering configuration with two motor-driven wheels and one passive follower wheel or caster. This kind of wheel configuration allows the robot to spin in place about the vertical axis for maneuvering in congested areas.

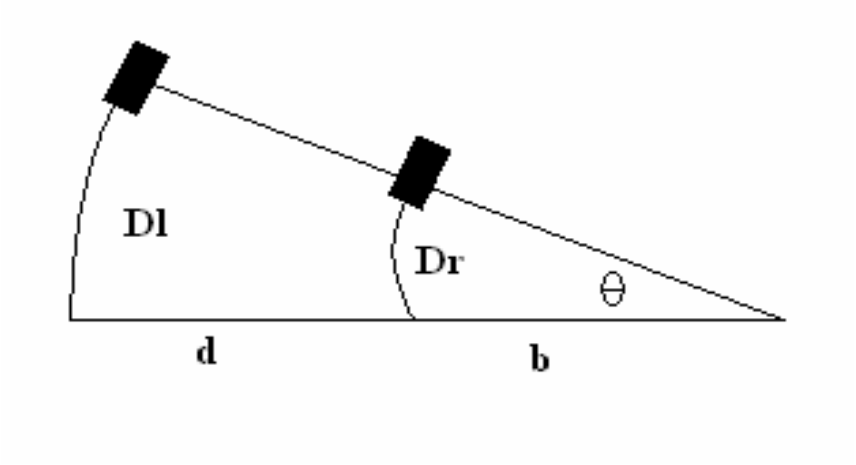

Figure 3. *Differential steering*

Robot displacement D along the path of travel is given by the following equation

$$D = (D_l + D_r) / 2 \quad [1]$$

where, D is the displacement of platform, D_l is the displacement of left wheel and D_r is the displacement of right wheel. Similarly, the platform velocity V is given by the following equation

$$V = (V_l + V_r) /2 \quad [2]$$

where, V is the velocity of platform, V_l is the velocity of left wheel and V_r is the velocity of right wheel. To avoid a slight error in turning, the system is fixed with a roller ball as a caster wheel. This kind of wheel could directly turn without adjusting its position like common caster wheel. This will avoid misdirection.

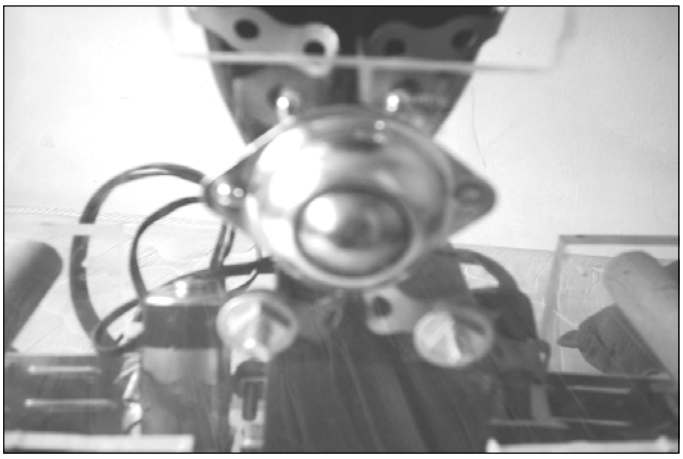

Figure 4. *Roller ball*

2.3 Complete Electronic Circuit

The whole circuit of the Intelligent Vacuum Cleaner Mobile Robot is the integration of the microcontroller circuit with the L293D motor driver circuit, the relays circuit and the sonar circuit. The complete schematic diagram of the circuit is shown in Figure 5.

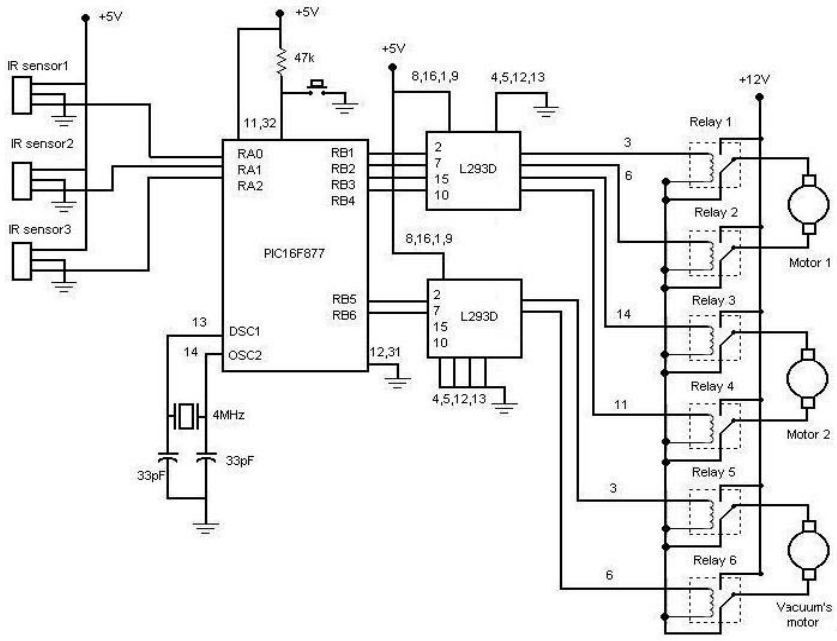

Figure 5. *The schematic diagram of the circuit*

2.4 Microcontroller

The electronic system of the robot is controlled by a PIC16F877 microcontroller from Microchip. The microcontroller has 40 pins which can be used as inputs or outputs pins. This means that the system could be enhanced to be more sophisticated in the future. The advantages of this microcontroller that it is easy to program and compact in size. We can use C language or assembly language to program it. We can only fix the microcontroller only onto our circuit without the programmer circuit. This would save the space of the electronic part. The PIC (Peripheral Interface Controller), like the CPU, has calculation functions and memory, and is controlled by the software. However, the throughput and the memory capacity are low. Depending on the kind of PIC, the maximum clock operating frequency is about 20 MHz and the memory capacity (to write the program) is about 1K to 4K words. The clock frequency determines the speed at which a program is read and an instruction is executed. The throughput cannot be judged with the clock frequency alone. It

changes with the processor architecture. However within the same architecture, the one with the highest clock frequency has the highest throughput.

2.5 Vacuum mechanism

For this mechanism, we used a ready made handy vacuum which available in the market. The vacuum that we are using requires 12 volts D.C. voltage with 60 watt power. This vacuum is fixed onto the mobile base. The motors of the vacuum could be reversed in polarity in draining process.

3. Robot Motion

There are four basic movements of the robot; move forward, turn left or right, rotate left or right and stop. When switch on, the robot will check all the input from the sensors and if there is no obstacle detect, it will start to move straight forward until any sensor is giving signal means that obstacle is detected. The turn left or right motion is applied when one of the sensors on the left or right side of the robot is detecting object. For example, if the left sensor giving input, the right motor will be paused a bit so that the robot will turn to right until no input from the sensor anymore. The rotate function will only be applied when object is detected in front of the robot. For example, if the front sensor detects an object, the robot will stop and start to rotate for a certain period by moving both motors in an opposite direction with the same speed. This will make the robot to rotate without requiring space bigger than its body. For more complex motion we can manipulate the inputs from the sensor and the speed and direction of the motor by programming. For example, we include conditions when more than one sensor is detecting objects. If left and front sensor are detecting object, the robot should rotate to right until no object detected. If all three sensors on the left, right and front are detecting object, the robot should reverse until no object detected anymore.

4. Software and programming

The software used for programming the robot is called MPLAB. We built the program for the robot using this software and it is written in C language. The program written in this software is saved in .HEX file which is readable by the software used to download the program into the microcontroller. In this process, we used a programmer circuit

where the Microcontroller is fixed onto it and the programmer is connected to the computer through any parallel port. Inputs for the program built are the sensors and switch while the outputs are the motors for wheel and the handy vacuum cleaner.

5. Experiments

Two sets of experiment have been done to measure the performance and the efficiency of the robot. The robot is needed to move on a space to be cleaned with a perimeter of 2 by 2 meters.

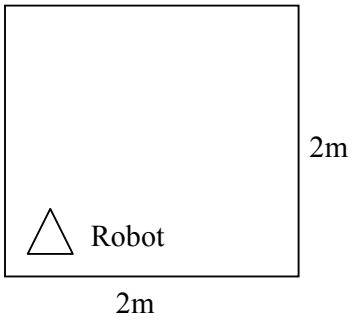

Figure 6. *Experiment No. 1 (without obstacles)*

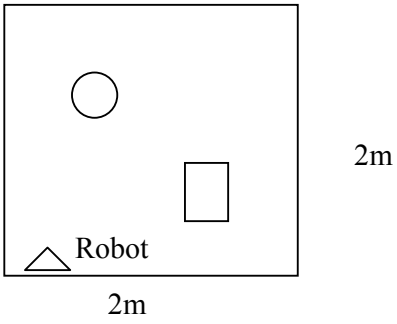

Figure 7. *Experiment No. 2 (with obstacles)*

The first experiment was done where there is no obstacle on the floor and the robot move freely and randomly until it covers all the space to be cleaned. In this case, the robot could smoothly move within the specified area without hitting the wall built around the test area. It

took 5 minutes for the robot to cover all the specified area. In the second test, the specified area is filled with some obstacle as shown in the figure, and the robot is needed to cover all the space for cleaning while avoiding the objects on the floor. By moving randomly and freely, the robot could move around the area and avoid the object and

6. Conclusion

Generally the design of the robot is successful where the main functions of the robot are working as planned. The robot could move smoothly forward and turn left and right when it detects any obstacle. The robot also could rotate itself whenever the space for turning is insufficient. Simultaneously, the vacuum on the robot will clean the dust on the floor. Another important aspect of the design of the robot is that it is low cost. This is an advantage if the robot is going to be mass produced commercially. This robot is easily upgradeable so that it can be developed to be more sophisticated and beneficial. Finally, the inventing of this mobile robot will be an initiative for more beneficial innovations to be developed in the future.

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