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Autonomous Cleaning Vehicle for Various Platforms

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Abstract: ***Objective of the project is to design and develop a cost effective and efficient vehicle to clean a particular room and to provide a germ free environment. We here, try to present and imply an idea that, a device can clean the given room by its own. The system will include dust suction system, detergent sprinkling system and a wiping system. Device will be programmed to measure a given room using an ultrasonic sensor by which it will cover the complete room. Once the device has covered the entire room, the user can make the device clean only in the area where dust is present in the room by using image comparison.***

Keywords: Micro-controller (8051),Kiel µvision, Flash magic, Motor driver (L293D), Chassis, DC geared motors, Suction pump, Liquid pump, Stepper motor, Brushes, Spongy Material, Batteries.

1. Introduction

1.1 Aim of the Project

To develop a system or a device to have a clean uncluttered room.

1.2 Case Study

Till now, in today's world we have seen many devices that autonomously cleans the room by vacuum suction and we also have seen many human controlled device for wiping floors (majorly seen in airports etc,).These systems are not only costly but are also not suitable for every environment.

The drawbacks of limited working range, cost, less , huge size and mainly unsuited for every environment are overcome by the use of a microcontroller and other parts such as suction pump, liquid pump, vacuum pump and a mop. The Control of vehicle involves three distinct phases: perception, processing and action. Generally, the preceptors are sensors mounted on the vehicle. The ultrasonic sensor measures distance of the nearest wall and this data is used to plan the navigation. Processing is done by the on-board microcontroller or processor, and the task is performed using motors or with pumps.

The room is monitored using a camera which will keep taking photographs of the room after every interval. The photograph taken will be compared with an image of the same room when its completely dust free. These two images are converted to grey scale and compared using matlab after which the coordinated of the dust in the room is obtained. These coordinates are sent to the microcontroller which will make the vehicle move to that particular location and perform cleaning operation. and DC motors is given with 12V supply. After the completion of the software coding and the movement of the device, we design the mechanical assembly.

Firstly, we fit in the vacuum suction at the head to clean the dust particles. Secondly, at the center of the device, we have liquid pump sunk in the mixture water and detergent reservoir and the mixture is pumped on through the pipes (beneath the chassis) and pipes are suitably pinned to sprinkle water and the open end is given back to the reservoir. Thirdly, at the back of the device we have spongy material fixed such that it wipes the left water. For further efficiency, there is a stepper motor programmed to give an angled (say 120 degrees) movement to the brushes. The algorithm given to the microcontroller is in the fashion of saw tooth. Hence, through all these actions a given room can be cleaned properly.

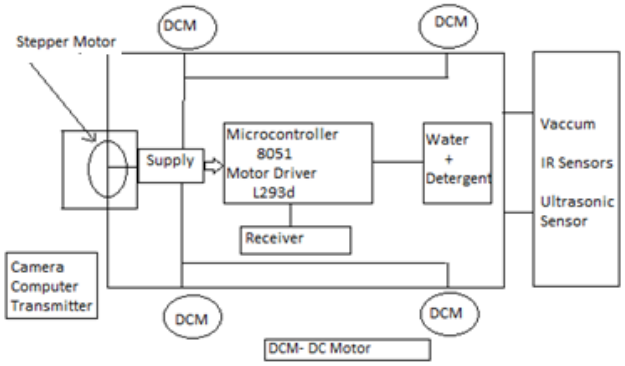

Figure 1: General Block Diagram

The general block diagram Fig.1 gives a brief idea of the system. In the present project the robot is controlled by a microcontroller which is connected to motor driver and supply. Here, the microcontroller is burnt with the code that is the C code using Kiel µvision and is burnt using Flash magic. The robot perceives this code and reacts accordingly to that code written. The port 0 of the microcontroller or any port from the 4 ports can be programmed and connected to the motor driver and respective supplies of 5V and 12V will be given.

Four motors will be connected in series with the L293D to act with the signals that are sent by microcontroller. In accordance to the signals we also have Infrared sensors that are placed in front of the device will detect any obstacle (say wall) and the signal from infrared signal will be passed to the interrupt pin of the microcontroller and the motors will react the interrupt signal received from the infrared sensor and left or right. Delay will be provided in the program after every

rotation. Saw tooth movement will be based on the infrared detection and the motion of the motors. Initially, as seen from the block diagram the dust will cleaned, sprinkling will be done, wiping is done and at the end blowing will complete the cleaning action for the area. The vehicle here once started will continuously run until the work is completed. Hence, no stopping of the vehicle may be expected once the vehicle starts until the end i.e. fulfillment of the job given.

2. Hardware Description

2.1 8051 Microcontroller

The microcontroller incorporates all the features that are found in microprocessor. The microcontroller has built in ROM, RAM, Input Output ports, Serial Port, Timers, interrupts and clock circuit. A microcontroller is an entire computer manufactured on a single chip. Microcontrollers are usually dedicated devices embedded within an application. For example, microcontrollers are used as engine controllers in automobiles and as exposure and focus controllers in cameras. In order to serve these applications, they have a high concentration of on-chip facilities such as serial ports, parallel input output ports, timers, counter, interrupt control, analog -to- digital converters, random access memory, read only memory, etc.

The I/O, memory, and on-chip peripherals of a microcontroller are selected depending on the specifics of the target application. Since, microcontrollers are powerful digital processors, the degree of control and programmability they provide significantly enhances the effectiveness of the application. 8 bit micro-controller means it can read, write and process 8 bit data. Basically 8 bit specifies the size of data bus. 8 bit microcontroller means 8 bit data can travel on the data bus or we can read, write process 8 bit data.

This is mostly used microcontroller in the robotics, home appliances like mp3 player, washing machines, electronic iron and industries MC 8051 has 128 byte Random Access memory for data storage. In 8051, 4KB read only memory (ROM) is available for program storage. This is used for permanent data storage. Or the data which is not changed during the processing like the program or algorithm for specific applications.

- This is volatile memory; the data saved in this memory does not disappear after power failure.
- We can interface up to 64KB ROM memory externally if the application is large.

2.2 Ultrasonic Sensor LV Max Sonar EZ0

The ultrasonic sensor provides very short to long range detection and ranging. The range is up to 255 inches. It requires a power supply of 2.5-5.5 V and draws current of 2mA.The sensor is mainly required to plan the navigation. The vehicle is placed at one corner of the room, the sensor measures the distance of the nearest wall ahead of it. The vehicle will now move as per the measured distance and then take a right. Now again this process is repeated 2 more times. After it takes the third right, the vehicle will move one foot less than the original measured distance thus the vehicle covers the entire floor in this fashion and finally stops in the middle.

2.3 Motor Driver L293D

The L293 and L293D are quadruple high-current half-H drivers. The L293 is designed to provide bidirectional drive currents of up to 1 A at voltages from 4.5 V to 36 V. The L293D is designed to provide bidirectional drive currents of up to 600-mA at voltages from 4.5 V to 36 V. Both devices are designed to drive inductive loads such as relays, solenoids, dc and bipolar stepping motors, as well as other high-current/high-voltage loads in positive-supply applications. All inputs are TTL compatible. Each output is a complete totem-pole drive circuit, with a Darlington transistor sink and a pseudo-Darlington source.

2.4 Liquid pumps

These liquid pumps feature excellent suction performance (3 mAq) and forcing performance (40 mAq) for the size as well as the self-priming capability. The products applying these pumps can be designed without restriction of the pump installation position with respect to the liquid level. With the liquid temperature range from 5C to 100C, these pumps are applied widely in equipment that needs compact design and/or self priming, such as home appliances (hot pots, refrigerators, water-spraying toilet seats, steam electronic ovens, irons and washing machines), housing equipment and fuel cells.

2.5 Vacuum pumps

Our vacuum pumps feature silent operation, low pulsation and long life. They are applied in products with which stable performance and operation are critical, such as medical equipment, measuring instruments and also in cleaning purpose.

2.6 Blower

This process relies on evaporation only and no heat is used. The process quickly dries the surface and since no heat is added, the heat of evaporation lost also cools the surface. Vacuum drying is used when critical processes require absolutely dry parts and is best suited for removing thin water films that are scattered on the surface. The vacuum system is the most energy efficient drying system available, requires minimum floor space and no exhaust connections outside the plant.

2.7 Stepper Motor

A stepper or stepping motor converts electronic pulses into proportionate mechanical movement. Each revolution of the stepper motor's shaft is made up of a series of discrete individual steps. A step is defined as the angular rotation produced by the output shaft each time the motor receives a step pulse. These types of motors are very popular in digital control circuits, such as robotics, because they are ideally suited for receiving digital pulses for step control.

Stepper motors provide a means for precise positioning and speed control without the use of feedback sensors. The basic operation of a stepper motor allows the shaft to move a

precise number of degrees each time a pulse of electricity is sent to the motor. The rotor of the motor produces torque from the interaction between the magnetic field in the stator and rotor. The strength of the magnetic fields is proportional to the amount of current sent to the stator and the number of turns in the windings. The rotor will require 24 pulses of electricity to move the 24 steps to make one complete revolution. Another way to say this is that the rotor will move precisely 15° for each pulse of electricity that the motor receives. The stepper motor can be operated in three different stepping modes, namely, full-step, half-step, and micro step.

2.8 Hardware Circuit Description

The controller i.e. micro-controller 8051 port 0 is connected to l293d motor driver. Then, it is given with 5V supply. Motor driver is given with 12V supply. All, the other hardware components such as vacuum pumps, liquid pump, stepper motor and blower is connected to 12V supply. Stepper motor is connected so that it gives angled movement for wiping and mechanical part is properly mounted and connected.

3. Software Implementation

Here, the microcontroller is programmed to achieve a proper output. Microcontroller is programmed and given to l293d motor driver and consequently motor will rotate giving device movement. Microcontroller port 0 or any port is connected to the L293D four input pins and then the output is given to the geared motor where the motion is controlled the flowchart is shown in fig 2. With the help of the ultrasonic sensor, the vehicle will cover the entire floor. After this the floor is monitored by a camera which takes photographs of the room after every interval.

A photograph of the same room when completely cleaned is stored in memory. The two images are converted to grayscale images and compared using a matlab code. Any error found will give us the coordinates of the area where dust is present. Now through a small local area connection, a signal is sent to the vehicle as a code. The microcontroller decodes this and obtains the coordinates of the area to be cleaned. Now this vehicle moves to this area and performs cleaning and once the cleaning is done. It moves back to the rest position which is in the corner of the room. The same process is repeated after a certain interval of time.

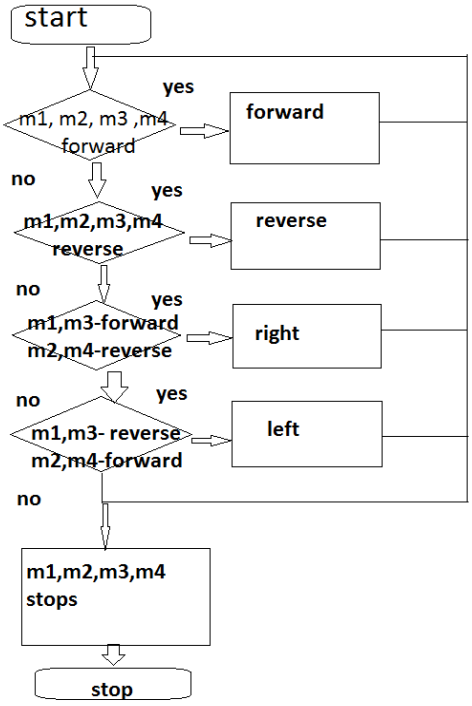

Figure 2: Flow Chart

4. Result and Analysis

The motor driver L293D can drive a DC motor with enable and control inputs. Micro-controller has to be specifically programmed to control the motion. Mainly, the mechanical assembly is carefully designed such that no circuitry damage is occurred due to the mixture of water and detergent. Since, use of both spongy material and stepper motor to and fro motion better efficiency is obtained. As far as the size is concerned, we have tried to reduce the size and can be further reduced. Coming to the cost, we try to use low cost and better efficient components. Mainly, we see that the cleaning is done properly and major efficiency is achieved.

5. Conclusion

In this paper, we have discussed about the self cleaning robot. We initiated our discussion by examining the motivation for the work. We then described the details for each component separately and how they worked together to bring on the whole project. We discussed about the micro-controller, motor drivers, sensors, camera and some mechanical assembly such as suction pumps, liquid pumps, blowers in together with sprinkling system. Finally the project has been developed by integration of all hardware and software component together. We have shown that by using an ultrasonic sensor, the vehicle can cover and clean the entire room and by using image comparison, the vehicle will clean only where required.

6. Applications

1) The main application of the project is to reduce the human effort by cleaning the surface automatically.
2) There is a choice of whether to clean the entire room or only for the area where dust is present.
3) The main application of this vehicle is at places where there is a need to minimize human work or where there is

a risk for a human to be present at the area like a nuclear plant.

4) It's most useful application we can say is that it can be used in nuclear power plants, where cleaning is the very important aspect and cleaning that surface is very risky, so it also avoids the risk.
5) Sufficient energy can be saved if image comparison is used as the vehicle will move and clean only for the dusty area and not the whole room.

7. Future Scope

1) It can be modified such that it can clean the roofs as well as ceiling with the creeping algorithm.
2) It can be used as demining robot if we integrate the military application to its feature.
3) In future modification, it can detect the intensity of the dust present in the room and clean as such.
4) By using Smart Intelligence property it can be used as self chargeable robot (if its battery charge is about to sink).
5) Its size can be minimized using nano technology and its speed can be improved.

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