University of Florida
Department of Electrical and Computer Engineering
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Intelligent Machines Design Laboratory

WOMAN
(Work-Oriented Mobile Autonomous Neat-freak)

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Abstract

WOMAN is an autonomous vehicle that randomly moves around a room vacuuming the floor as it goes. WOMAN monitors its battery and returns to its recharging station when it becomes low on power. WOMAN will demonstrate obstacle avoidance of walls as well as objects in the room (people's legs).

Introduction

Nobody likes a dirty floor. However, the solution to this is a task that few enjoy. Having to take the time and effort to sweep or vacuum a floor when you could be doing something much more productive (like watching TV) is highly undesirable. Hiring a maid to do this job for you can be very costly; therefore, another solution is needed. With great advances in technology we now have the power to not have to clean the floor, via a small, mobile floor cleaner, WOMAN. WOMAN roams around a room sucking up any dust or dirt on the floor. It avoids any obstructions in the room (walls, boxes, people), and when it gets low on battery power, it shuts down its vacuum (to save power) and finds its way back to a recharging station, where it recharges its batteries and sets off on another cleaning rampage. It can be left to do this all day long, or can be switched on at night to clean your floors while you sleep, and stay out of your way.

Integrated System

The robot uses a cylindrical platform for optimum mobility. Mounted on this are 2 hacked servos to drive the system. The brains of WOMAN is an Atmel ATmega163 microcontroller mounted on a MegaAVR development board. This chip has 3 PWM channels, two of which are used to control the speed of the servos. The IR detectors are two Sharp GP2D12 sensors mounted cross-eyed at 20 degrees from straight forward. Bumper switches surround the platform to sense the presence of an obstacle. Two CdS cells mounted in the back of pen caps are used for finding its recharging station, which uses a 60-Watt light bulb as its beacon, and temperature sensors are used to monitor the temperature of the batteries being recharged. A block diagram of this system can be seen in Figure 1.

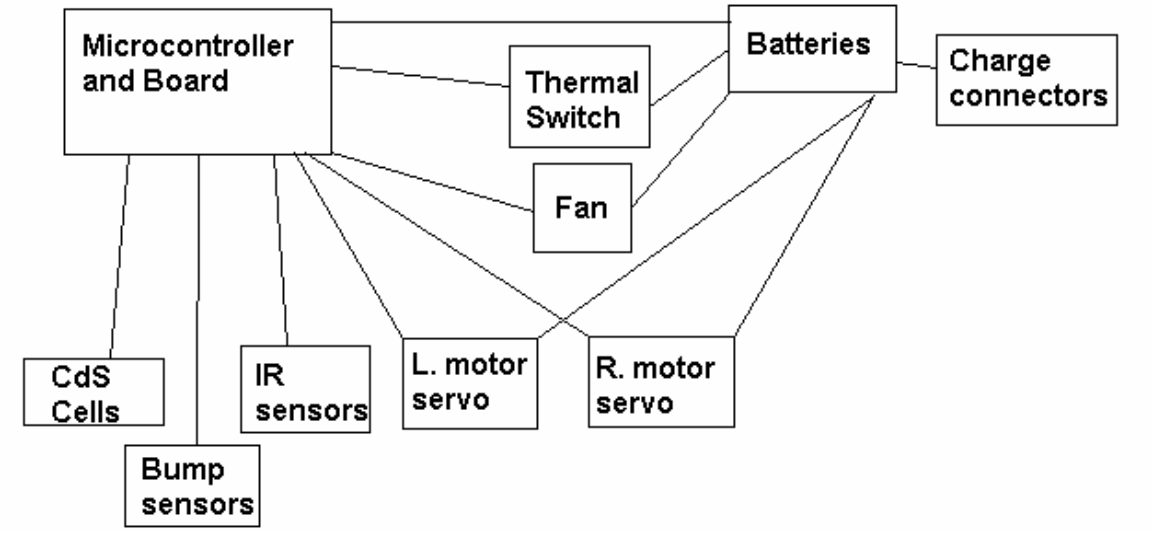

Fig. 1- Functional block diagram

Mobile Platform

The platform used for WOMAN is cylindrically shaped, in order to decrease the chances of the robot getting stuck where it cannot escape. This shape allows WOMAN to spin in place, enabling itself to easily escape from corners. The platform is 11" in diameter and 5" tall. The center of mass of the robot is near the rear of the platform, with the fan for the vacuum and the battery pack. A nylon bulb is mounted under the rear of the platform to support WOMAN (along with the 2 wheels connected to the driving servos). CdS cells are mounted along with the IR detectors at the front of the platform. The temperature sensors are mounted on the battery pack .

Actuation

Two hacked Futaba servos are used to drive and steer the robot. PWM, which is integrated into the ATmega163, is used to determine the speed and direction the motors will be running. The fan uses a separate battery pack to provide the amount of current needed to power it. Also, the fan is controlled by the microcontroller via a TTL logic relay to shut it down when the battery is low.

Sensors

The four types of sensors used in this robot are: IR detectors, Bump sensors, CdS cells, and temperature sensors.

Infrared

Two infrared detectors are used for this robot. These are mounted on the front of the robot and angled 20 degrees inward and detect the presence of objects in front of it. These sensors are the Sharp GP2D12 IR detectors which output an analog voltage relating to the amount of IR light bouncing back from an object. The closer the object (to a point), the greater amount of IR.

Bump Sensors

Six bump sensors are mounted around the robot to detect if the robot runs into anything. These are push-button switches with a solid 14-gauge copper wire surrounding the perimeter of the platform.

CdS Cells

Cds cells are used to locate the recharging station. The recharging station has a 60-Watt light bulb attached to it, low to the ground, for the CdS cells to detect. When WOMAN is low on batteries, it begins to look for a light source. Since these cells are mounted inside pen caps, their light-sensitivity becomes very directional. Experimenting with different resistor values for the voltage divider circuits, I found that for indoor applications with indoor lighting conditions, a 33kO resistor provides the optimum sensitivity. Testing was

does done on the mounted CdS cells to determine its ability to find the light beacon. A 60-Watt light bulb mounted inside a desk lamp, giving it a 100 degree swath, was placed on the ground. The robot was placed at various distances away and the CdS cell values were read at various rotations of the robot. The data collected is shown below in Table 1.

	0 degrees		20 degrees right		40 degrees right		20 degrees left		40 degrees left	
feet away	Left	Right	Left	Right	Left	Right	Left	Right	Left	Right
10	52	54	120	143	158	160	108	88	186	189
8	39	39	83	91	160	161	87	55	178	163
6	26	28	66	103	146	158	85	58	171	164
4	8	14	8	40	39	160	110	16	165	103
2	6	9	3	108	19	171	96	4	146	20
Note: the ambient room lighting gave values of 186 and 189, respectively.										

Table 1

Temperature Sensors

When WOMAN's batteries get low on power, it finds its way to a recharging station to recharge its batteries. A temperature sensor on each battery pack monitors the temperature of the batteries while recharging. If they get too hot, the batteries are recharged and the robot disconnects from the charging station and continues to clean. These were mounted with heatsink compound to get good thermal conduction from the battery pack to the temperature sensors. To find what values the temperature sensors read from the batteries the sensors were sampled during a 16 minute recharge. The results are shown in figure 2.

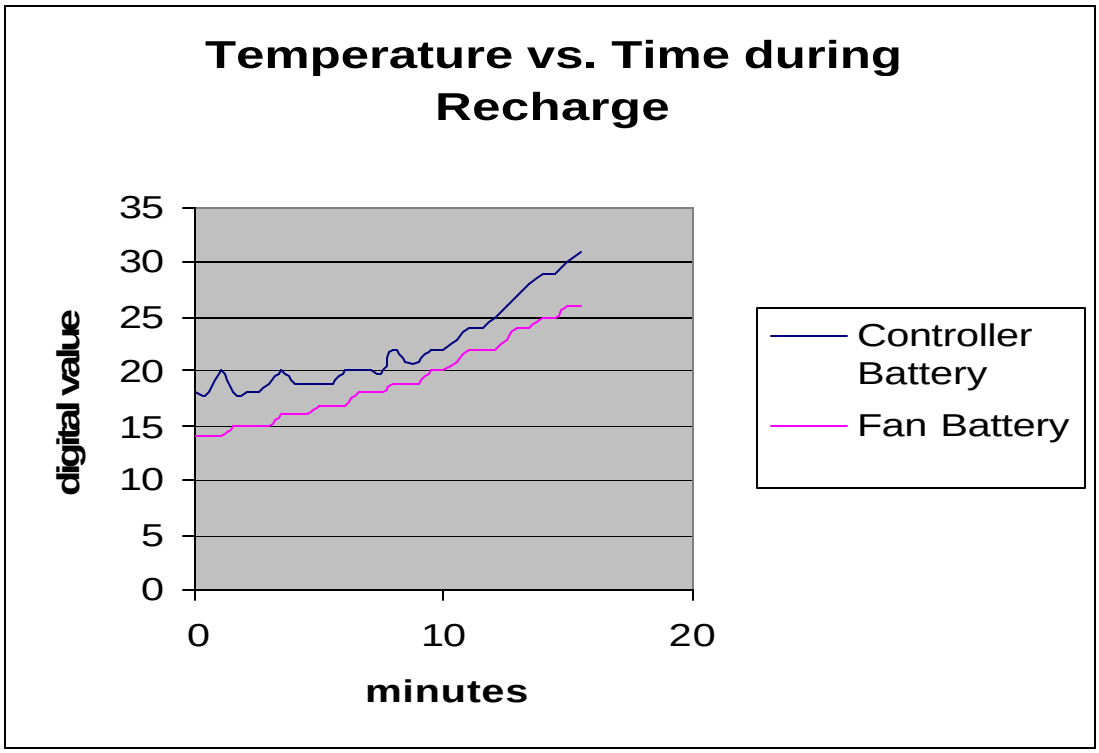

Figure 2

Note: the starting voltages for the controller and fan batteries were 7.68V and 9.79V, respectively. The final voltages were 11.14V and 11.31V respectively.

Behaviors

WOMAN will demonstrate obstacle avoidance by using its infrared and bump sensors. When and object is detected, it will choose a new random direction to follow. This ensures that the ROBOT won't take the exact same path every time it is activated, so it will most likely cover the entire room to be cleaned using a very simple programming algorithm. When WOMAN becomes low on batteries, it will shut down its fan to conserve power and search for its recharging station. WOMAN will use a dizzy search method to find the recharging station. This means that it will start monitoring its light

sensors, looking for a high amount of light. Every 10 seconds it will spin in place, checking the light sensors every 100 ms. Once a light source is found, it will recharge its batteries and then continue cleaning.

Conclusion

WOMAN will be a very useful robot using a simple roaming procedure to clean a room. It will be a small, relatively quiet, low-maintenance robot that can accomplish a common household chore autonomously; leaving you with more time to do the more important things in life.