ROBOCAR: DESIGN IMPLEMENTATION AND TESTING OF A ROBOT CAR

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ABSTRACT

This study was conducted to design, construct and test the performance of a Robot Car. Specifically, the study aimed to develop a working prototype of a microcontroller driven LEGO car; develop step-by-step instructions for building a Robot Car; test the performance of the Robot Car using a circuitous track made of black electrical tape; determine the average illumination levels for the photo resistors to react either to stop or steer the car; and to measure the effective distance for the infrared sensor to give appropriate signal for a possible obstacle in the path. The "Robot Car" used embedded control in the form of a microcontroller board and was designed to follow a path made of black electrical tape on a white background. The track was a circuitous course that contains 3-inch long strips of electrical tape perpendicular to the main track. These strips are long enough to overlap all three sensors on the line-tracker. Results revealed that if an obstacle, about eight (8) inches far, is encountered the vehicle stops until that path is once again clear. The photo resistors allowed the car to be steered by a flashlight or to stop when ambient light decreases to approximately 5 lux. The development of a prototype ROBOCAR will allow students in the course, Embedded Computer System Design, to design, build, and debug their own robot that will play in a competitive performance event. The hardware, software, and other information they need to design, build, and debug their own robot are provided by this study. This will enhance students' interest about robotic design and other applications that are revealed to various Software Engineering classes.

INTRODUCTION

Background and Rationale

Embedded Computer System Design is an interdisciplinary course which requires students in one semester to design, build, and debug a robot that will play in a competitive performance event. The goal is to teach students robotic design by giving them the hardware, software, and information they need to design, build, and debug their own robot. The subject includes concepts and applications that are related to various Software Engineering classes. In this course, students learn to expect the unexpected as they face with a myriad of challenges in implementing their ideas. It is expected that students leave the course with a greater appreciation of the complexity of the real world, and with pride of their own accomplishment as designers. To give students some important concepts and an example on robotic design, this project was proposed and conducted.

The project which is called "RoboCar", a microcontroller driven LEGO car, includes the design and construction of a vehicle equipped with an embedded controller and sensors capable of performing a variety of programmable tasks including interactions between the mechanical, electrical, and software subsystems for the car. The embedded controller utilizes a Motorola 68HC11 microcontroller. The Handy Board is a 6811-based microcontroller system that lets you build mobile robots for educational, hobbyist, and industrial purposes.

Objectives of the Study

This research aimed to develop a working prototype of a microcontroller driven car based on the Handy Board robot controller design. It is a fledgling project that presents some of the contents of our proposed Embedded Computer System Design Project in a more traditional form. Step-by-step instructions for building a robot car were also developed and it will serve as a guide for beginners who want to explore the world of Embedded Computer System Design.

DESIGN AND ASSEMBLY

The Handy Board

The parts of the Handy Board are arranged in labeled bags (Nos. 1-5) and in different anti-static bags for easy identification and handling of parts. Assembly tools, sequence of assembly and a brief description of the different parts of the Handy Board are outlined below.

Hardware and Software Assembly Tools. The different equipment used in assembling and in testing the Handy Board are as follows:

a. X-acto
b. Pliers
c. Soldering Iron
d. Sn60 Solder
e. Spare Wire
f. Wire Clippers
g. Grounding Strap (or other anti-static measures)
h. Small Phillips Screwdriver
i. Scotch or Masking Tape
j. Small File (even a fingernail file will do)

k. Voltmeter (any model, digital or analog, will do)
l. Logic Probe or Oscilloscope
m. Lux Meter

The Interface/Charger Board. The assembly begins with the Interface/ Charger board because it is the simpler of the two boards, and because it will be used when testing the Handy Board itself. The parts to be used for this assembly sequence are contained in Bag No.1 and in the Anti-Static Bag. The assembly includes power circuit installation, interface/charger serial circuit, interface/ charger board charge circuit and Jacks. The completed Interface/Charger Board is shown in Fig. 1.

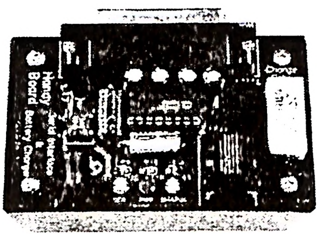

Figure 1. The completed Interface/Charger Board.

Power, Power Monitor, CPU, and Serial Line Circuitry. The parts to be used for this assembly step are contained in Bag No.2 and in the Anti-Static Bag that includes the assembly of the Microprocessor Power Circuitry, Debugging the Charge LED and Power Switch, Voltage Monitor Chip, and Debugging the Voltage Monitor Chip. In this assembly sequence, the 6811 power supply and power monitoring circuitry, the 6811 unit, and the serial communications circuitry are installed

Memory Circuitry. The parts used in memory circuitry are contained in Bag No. 3 and in the Anti-Static Bag. In this assembly sequence, the 32K static memory is installed and tested. The beeper and the LCD screen are installed, and the Interactive C is brought up on the Handy Board. Assembly of Memory Power Circuit, Debugging the Memory Power Circuit, Memory Addressing Latch, Memory Chip and Decoding Gates, and Debugging the Memory Chip and Decoding Gates are also completed in this step.

Motor Output Circuit. The parts of the motor output circuit are contained in Bag No. 4. The motor output circuit consists of a digital output latch (U8, a 74HC374), two high-current motor driver chips (U10 and U11, L293D's), and eight LEDs to indicate motor state.

Analog Inputs. The Handy Board analog input bank connected directly to the 6811's analog inputs.

Infrared Input and Output. The Handy Board Sharp IS1U60 infrared demodulator is a device used to decode common household TV and VCR infrared transmissions. It also has an oscillator and power output stage for driving infrared LEDs to generate such signals.

Fuse, Battery Wiring, and Final Assembly. The fuse and battery wiring is the final series in the Handy Board assembly. In this sequence, the PolySwitch resettable fuse and the 9.6 V rechargeable battery pack are installed. The parts needed for this assembly step are contained in Bag No. 5 (Figure 2).

For the final assembly, the Handy Board is flipped on top of the battery pack and is mounted in the place using the self-tapping screws and nylon washers. The washers are mounted between the board top surface and the screw heads. Four flat four flat LEGO pieces are then glued to the underside of the case. LEGO pieces are first mounted on a base plate to install them at valid LEGO spacing (Figure 3).

The completed Handy Board should be able to talk to WinBug11 and should allow WinBug11 to access its memory unit.

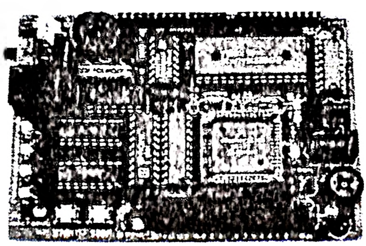

Figure 2. The Main Board with the Fuse Installed.

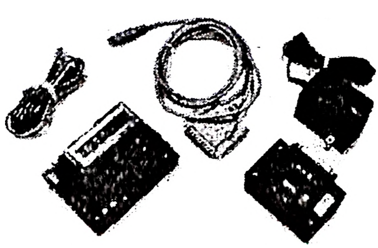

Figure 3. The Complete Handy Board and Accessories.

Lego Car

The Lego car kit is a battery-operated toy where the Handy Board is mounted. Assembling the car kit is carefully done so as not to cause short circuit of an unconnected cable. To demonstrate the correct operation of a DC motor, a test program is developed that will allow the motor to respond to the commands.

Line Tracker

Line tracker board was mounted to the vehicle to allow it to follow a certain path.

Collision Avoidance System

Collision avoidance system allows the car to be steered by a flashlight or to stop when obstacle is detected. Prior to the assembly of the system, experiment was done with the photo resistors to determine the proper analog values for ambient light and the flashlight. Proper operation of the collision avoidance system is determined by writing a program that stops the vehicle when an obstacle is detected and then restarts it when the obstacle is removed.

PERFORMANCE TEST RESULT

The ROBOCAR followed the path of black electrical tape on a white background. The track was a circuitous course that contains 3-inch long strips of electrical tape perpendicular to the main track.

Figure 4. The Complete ROBOCAR Moving on a Track.

These strips are long enough to overlap all three sensors on the line-tracker. When such a strip is encountered, the vehicle toggles its speed. This means, that if the vehicle is moving at its fast speed, it cuts its speed in half and if doubles it when moving at its slow speed (Figure 4).

The vehicle starts in fast speed, but it also avoids collisions with any obstacle in its path. If an obstacle, about eight (8) inches far, is encountered, the vehicle stops until the path is once again clear. The photo resistors connected to PE5 and PE6 allow the car to be steered by a flashlight or stop when ambient light decreases to approximately 5 lux.

CONCLUSION AND RECOMMENDATIONS

The development of a prototype of a ROBOCAR will allow students in the course, Embedded Computer System Design, to design, build, and debug their own robot that will play in a competitive performance event. The hardware, software, and other information they need to design, build, and debug their own robot are provided by this study. This will enhance students' interest about robotic design and other applications that are related to various Software Engineering classes.

To further enhance the robot performance, it is recommended to design an operating system that could take care of all the programmable functions including interactions between the mechanical, electrical, and software subsystems.

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