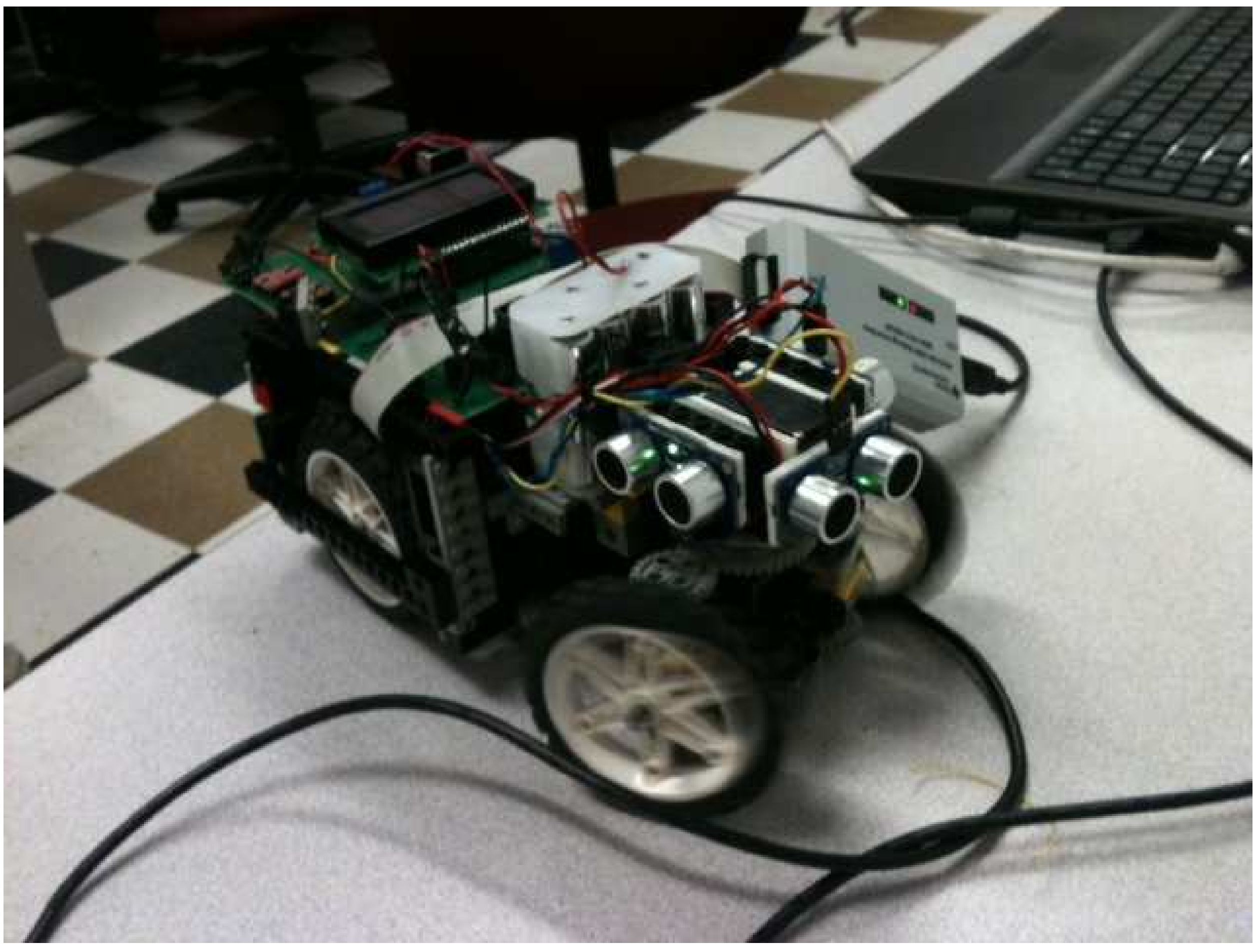
Obstacle Evading Ultrasonic Robot

Aaron Hunter
Eric Whitestone
Joel Chenette
Anne-Marie Cressin



ECE 511 - Fall 2011

Abstract

The purpose of this project is to demonstrate how simple algorithms can produce useful behavior in a robot. The goal is to design and implement a self navigating robot using a drive motor, steering servo, an MSP430 microcontroller, and ultrasonic sensors.

Initially we used 6 Ultrasonic Range Finders which communicate through I2C interface, however several were damaged. We then purchased different sensors which were more robust.

The robot was fully functional a few days after the presentation, starting from 12/16/ 2011.

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1. Motivation

The motivation for the project is to demonstrate the use of simple algorithms in a system that uses sonar technology to detect and avoid obstacles. Even though underlying communication and integration of components may be complex, the communication is abstracted from the simpler logic used for course correction.

2. Solution

The Evading Ultrasonic Robot uses a proportional algorithm with the readings from the ultrasonic sensors to calculate the course correction parameters. The robot successfully navigates by following the closest wall.

Steering is accomplished through a simple proportional algorithm. The smaller the value produced by the left-facing sensor, the closer you are to an obstacle on the left, the more to the right the wheels are oriented. The larger the value, the more to the left the wheels move. This produces a wall following behavior as the robot moves forward.

The front sensor is used to turn the wheels to the right when the vehicle is getting away from an obstacle.

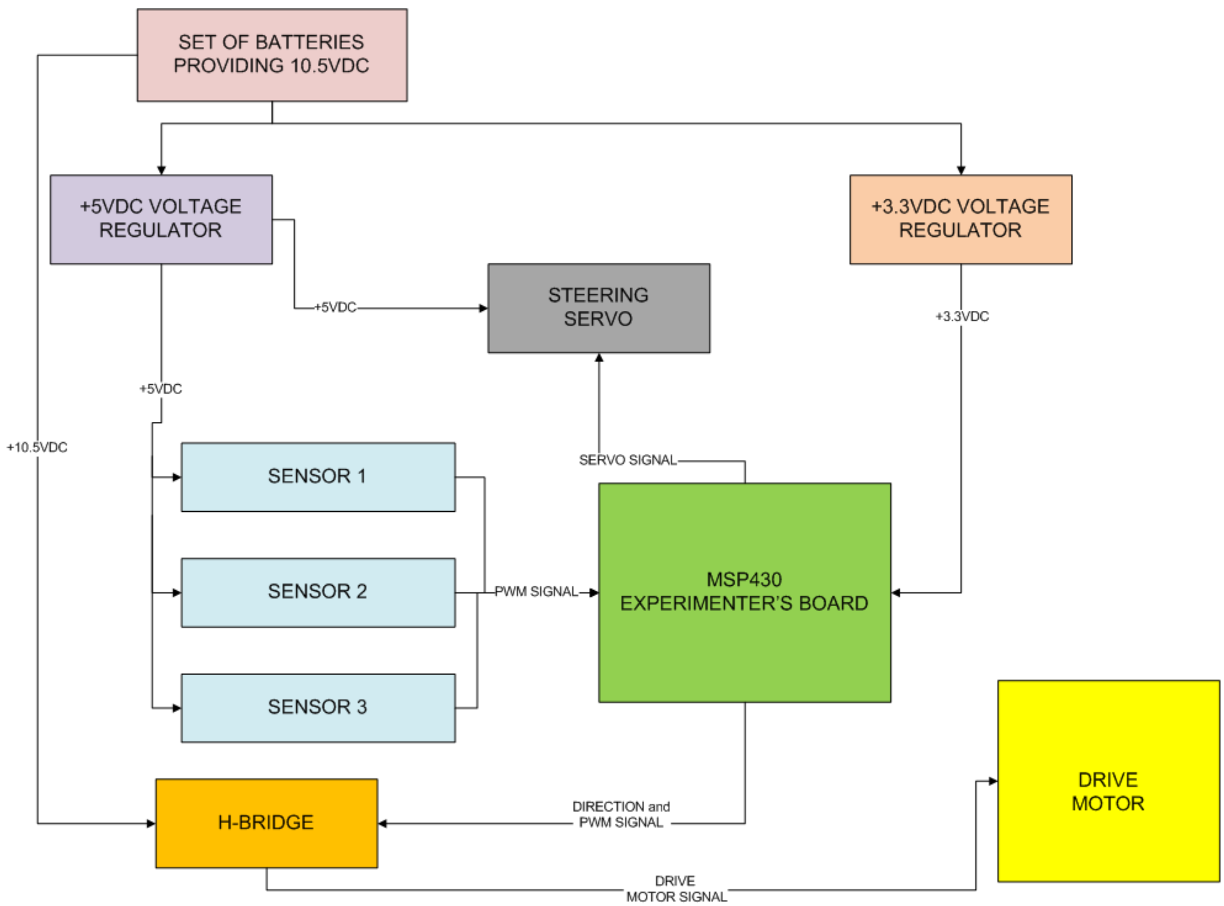

Figure 1: Top-Level Block Diagram

3. Part Description

3.1 Interfacing with the sonar sensors

The software interfaces with the new Ping))) Ultrasonic sensors through Pulse Width Modulation. The original sensors that were used interfaced with software using I2C. Timer B and three capture registers are used for interfacing with the sonars.

The MSP430 interfaces with the sensors using a single bidirectional wire to each sensor. Timer B is used to produce an interrupt every 22 msec. This interrupt creates a 16 usec output pulse to all three sensors. This pulse activates the ranging sequence for the sensors. Before the ISR sensors exits, all three lines are set as inputs. Once the ranging sequence begins, each sensor pulls its data line high and sends out a 40 kHz ultrasonic pulse. When the echo pulse is detected, the sensor pulls the line low. This action triggers a capture event on the capture/ compare registers of Timer B. Each line is connected though a different capture register, and when the interrupt is activated again all 3 of these registers are read and used to steer the robot.

3.2 Interfacing with the Servo and Drive Motor

The steering servo and drive motor are controlled using Pulse Width Modulation. Timer A was used to generate these two PWMs signals using Up Mode.

The steering servo requires a waveform that has a high pulse of 1.3 to 1.7 ms with a 20 ms period. The 20 ms frequency was selected by the undivided SMCLK with a TACCR0 value of 10000. In order to create the high pulse, the CCR1 was set to OUTMOD_6 with a TACCR1 value ranging from 9120 - 9380.

As a 20 ms period was sufficient period to drive the rear wheel motor, we were able to use the same timer for the wheels as well. The CCR2 was set in OUTMOD_6 with a value ranging from 0-9999 in order to create a PWM with a duty cycle from 0% to 100%.

4. Results and Conclusion

The Obstacle Evading Robot successfully avoids obstacles. Simple algorithms used to calculate steering and speed correction, successfully navigated the vehicle. At its conclusion, the initial vision of the robot materialized. The team successfully interfaced every component that was originally planned. Much time and effort went into the discovery process in learning how the different protocols operate.

A major lesson learned while developing the robot was with debugging communication protocols. If the behavior of components is unexpected or unpredictable, always view the signals on an oscilloscope and compare the signals with the signals emitted from components that are known to work.

Secondly, the testing of components as soon as possible will not only help in proof of concept early on, but also alert those involved to defective hardware. It is important to get a proof of concept early on, so that design changes can be made before time becomes a major issue.

Youtube Link to working robot

http://www.youtube.com/watch?v=WjgriUa5U7Y&feature=mfu_in_order&list=UL

5. Appendix

5.1 Roles/Responsibilities

Anne-Marie Cressin - Hardware schematic, PCB Layout, hardware integration, presentations, report
Joel Chenette - Hardware selection, hardware integration, I2C with old sensors, PWM for new sensors, assist with report
Aaron Hunter - PWM for drive motor and steering servo, hardware integration, assist with presentation, assist with report
Eric Whitestone - I2C with old sensors, assist with hardware integration, assist with presentations, report

5.2 Parts List

Description	Qty	Manufacturer	Manufacturer Part Number	Price per Unit	Total Price
Microcontroller	1	Texas Instruments	MSP430G2203	$2	$2
Ultrasonic Range Finder	6	Devantech LTD	SRF02	$24.50	$147
H-Bridge	1	DFRobot	DRI0002	$22	$22
Steering Servo	1	Hitec	HS-322HD	$10	$10
Voltage Regulator, 5VDC, 3A, with heatsink	1	Linear Technology	LT1085CT-5#PBF	$10	$10
Adjustable Voltage Regulator, used to provide 3.3VDC, with heatsink	1	National Semiconductor	LM317	$5	$5
Random connectors, perfboard, etc…	n/a	n/a	n/a	$20	$20
Ultrasonic Range Finder	3	Parallax	28015	$30	$90
Set of Batteries	1	n/a	n/a	n/a	n/a
Total Project Cost					$306

5.3 Full System Schematic

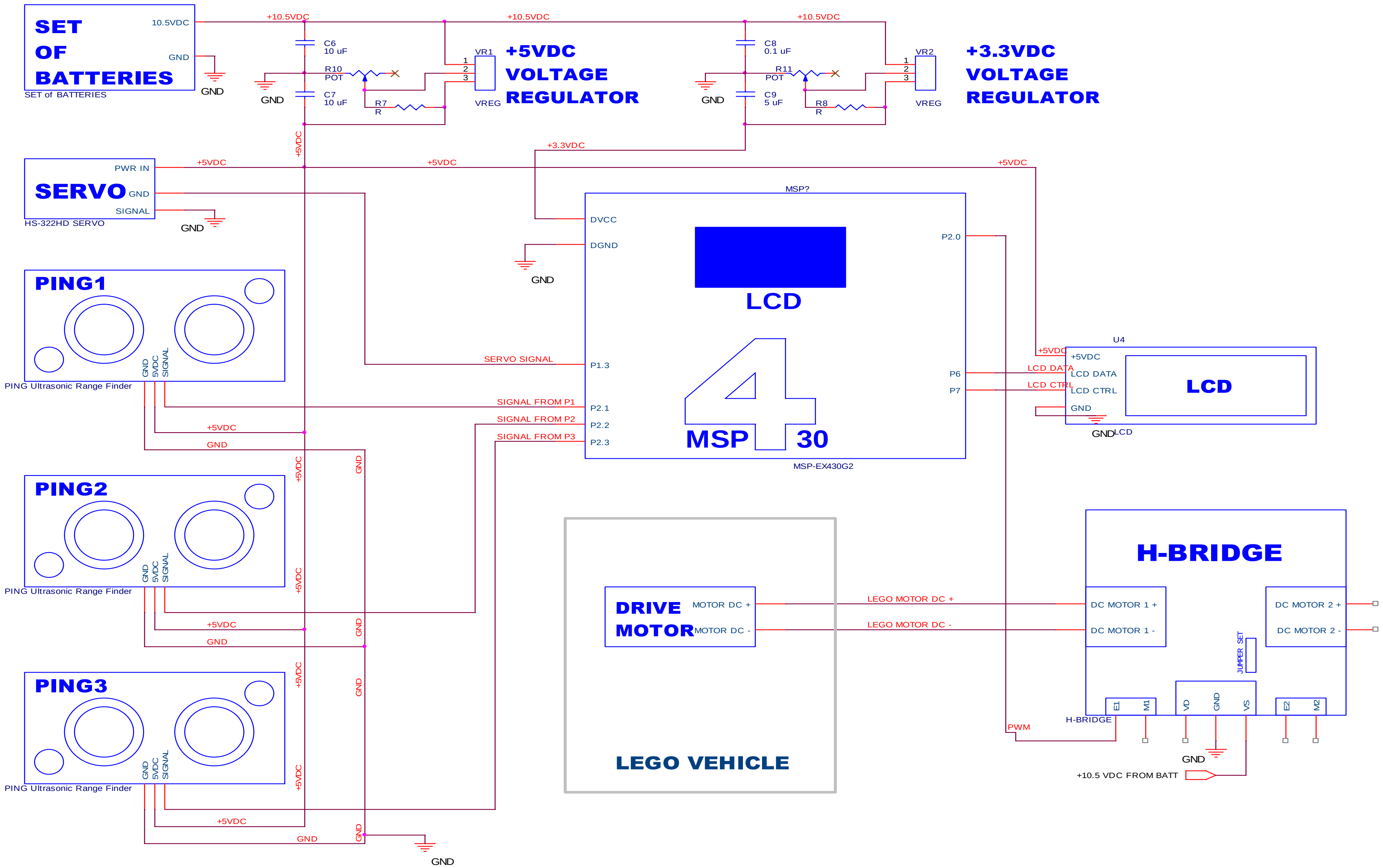

Figure 2: Full System Schematic