Self driving Robot Wagon

I did this project just for fun. It is a self driving Robot Wagon using a PIC Microcontroller and three HC-SR04 Ultrasonic Distance Sensors.

I purchased a Robot kit from Ali-Express, consisting of a chassis with two motors, a battery holder for 4 AA batteries, and an on/off switch. When using 4 rechargeable batteries the motors did not always want to start because the Voltage was apparently too low. So I replaced the battery holder by one that could hold 5 AA batteries. Due to the required 6 Volt, I used a Voltage Regulator of 3.3 Volt for powering the electronics. Only the motors operate at 6 Volt.

Supplies

The motor driver is built with transistors, so not an H-bridge module. Because of that you need quite some components. You need to have the following components for this project:

- One Robot kit with chassis, 2 motors, on/off switch and 1 battery holder
- A piece of breadboard
- 1 * PIC Microcontroller 16F1823 and socket
- 1 * 74HC4052 Analog Multiplexer and socket
- 3 * HC-SR04 Ultra Sonic Distance Sensors, the newer ones that can operate at 3.3 Volt
- 1 * 3.3V Voltage Regulator MCP1702-3V3
- 4 * transistor BC639, 4 * transistor BC640, 4 * transistor BC547
- 8 * diode 1N4148
- 2 * Green LED 8 mm, 1 * White LED 8 mm, 1 * Amber LED 5 mm
- 12 * Resistor 10k, 4 * Resistor 1k, 4 * Resistor 330 Ohm
- 1 * Electrolytic Capacitor, 1000uF/16V
- 2 * Capacitors 1uf, 3 * Capacitor 100 nF
- Optional: 6-pin Female Header to connect the PIC programmer

The hardware design

The schematic diagram consists of two parts:

1. Power Supply, PIC Microcontroller, Analog Multiplexer and connection to the HS-SR04 sensors

2. Motor Driver build with transistors.

The heart of the self driving Robot Wagon is of course the PIC Microcontroller. The Microcontroller uses the three Ultra Sonic Distance Sensors one after another using the Analog Multiplexer IC and receives the distance from the left sensor, the center sensor and the right sensor. In order to change the speed of the Robot Wagon, Pulse Width Modulation (PWM) is used to control the DC-motors. Since the Motors require 6 Volt and the maximum allowed Voltage for the PIC is 5.5 Volt, a 3.3 V Voltage Regulator was used to power the PIC Microcontroller the Analog Multiplexer and the Ultrasonic Distance Sensors. Note that for the Ultrasonic Distance Sensors you need to have the newer models that can operate at 3.3 Volt.

The Motor Driver Circuit is build with Transistors. Some protection diodes are used to protect the transistors from spikes generated by the Motors. The driver circuit is build in such a way that only two signals are needed to control the speed and direction of one motor.

Building the Wagon and the Electronics

The kit comes with a small manual and all the screws you need. There was enough room on the chassis for mounting the breadboard but I needed to drill some extra holes.. The Ultrasonic Distance Sensors where mounted using the special braces that are made for these modules Since I did not have the tiny screws to mount the modules to the braces, I used hot glue.

After having build the self driving Robot Wagon, I decided later to add some head lights in front of the Wagon. Because that the current limiting resistors for those LEDs are not on the breadboard. A picture with the LEDs on is shown.

The picture of the breadboard shows how the circuit was built and how it all fits on the chassis.

The Software

The software is written for a PIC16F1823 using the JAL programming language b you can also use any other PIC as long as it has sufficient Flash, RAM and two timers. The software uses 1486 bytes of Flash and 78 bytes of RAM. This PIC can handle 2 kByte of Flash and 128 bytes of RAM so there is still space to add some extra features to it.

The software does the following:

- It obtains the distances from all three Ultrasonic Distance Sensors by checking them one after another. The JAL library for the HC-SR04 sensor is used for that. This library uses Timer 1 of the PIC Microcontroller to measure the distance and returns it in mm. Since only one sensor can be measured at the same time, the PIC Micontroller multiplexes the sensors using the 74HC4052 analog multiplexer.

- After having received all measurement, the distance of al sensors are checked. If the distance is larger than 35 cm for all sensors, the Robot Wagon goes forward. If one of the sensors measures a distance of less than 35 cm but more than 20 cm, the speed of one of the motors will increase and the other will decrease so that the Wagon turns slightly. If the distance is less than 20 cm, one motor will stop and the other motor will be at maximum speed so turning will be more abrupt. If the distance to the center sensor is less than 20 cm, the Wagon will go backwards.

- In order to control the speed of the Motor, Pulse Width Modulation is used using Timer 2 of the PIC Microcontroller. Generation the PWM signal is done in software since two motors needed to be controlled and this PIC only has one PWM hardware module (which is not used).

- Each time the distance of one of the sensors is less than 35 cm, the Amber LED on the breadboard will be turned on to indicate that the Robot Wagon has to change its direction.

- If for some reason no valid distances are measured, e.g. when the Wagon is too close to an obstruction, the Wagon will automatically go backwards after some time.

It sometimes happens that the Wagon gets stuck in a certain position so there is still some room to optimize the driving algorithm.

Demo

The video shows the Robot Wagon in action after powering it on. Sometimes it looks as if the Robot Wagon is 'thinking' what it needs to do but this is caused by the fact that when the distance becomes too small the motor speed is set to zero, after which it slowly increases. This takes some time.

If you are interested in using the PIC microcontroller with JAL – a Pascal like programming language – visit the JAL website at: http://justanotherlanguage.org/

Link: https://youtu.be/kwYxd5GjtCw