Project Report
Self Driving Car

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Contents

List of Figures

List of Tables

Abstract

In this course project report, we will discuss the electric and mechanical implementation of the obstacle avoiding car and its embedded c program code development. The car is autonomous where it depends totally on pre-programmed c code (in other words there is no user interface to control the car). The used microcontroller is Atmega328 thats contained in the Arduino Uno I/O board type. We used two Ultrasonic sensors (HC-SR04) to detect the obstacles based on their location (left side or right side), as well as H-bridge and pulse width modulation to control the velocity and the direction of the car. Moreover, an LCD to display each of time elapsed and driven distance to compare results in competition. We designed a State chart design to increase the accuracy of detecting and avoiding the obstacles comparing to other cars. The car is provided with DC 4 motors supplied by two lithium batteries.

1 Introduction

1.1 Motivation

Obstacle avoiding cars are vehicles controlled using micro controller and are programmed to avoid the faced obstacles through its path autonomously. Obstacle avoiding car uses Ultrasonic sensors to detect the external environment that surrounds it and then based on embedded c program and the inputs from the sensors, it takes list of instruction to overpass the faced object. Thus, avoiding obstacle car is crucial principle for Self-driving car that are under-development until now. Therefore, the main part in this project is the effectiveness of the code that makes the car smart enough to deal with different environmental random obstacles that may face.

1.2 Literature review

Arduino boards are small electronic circuits that includes a micro controller called AT-mega micro. There are multiple types of Arduino boards were their pin numbers, size, and capabilities differ but their functionality stays same. Arduino can supply up to 5 v and sustain up to 20 v; with 14 digital I/O pins (6 of those provide PWM output) where each supplies DC current of 40 mA. Arduino boards can be used to create many different kinds of projects and in our Case Arduino Uno the main component where the robot was build around as the digital I/O pins were used to control nearly every device used while also being as a voltage and ground source for multiple components.

1.3 Problem Statement

In this course project as a group, we aimed to build and design obstacle avoiding car that will compete the cars of other groups. The car is autonomous and based on Arduino Uno and use Atmega328 as micro controller. The car should have the capability to cross a path no less than 20 meters that is provided with random obstacles with zero hits and minimal distance and time elapsed. Therefore, for comparing purposes, each car should be supplied with LCD display to work as an assessment tool. However, each of design, connection management and effectiveness of embedded c code are taken into consideration as a part of assessment tools. The code development is not

necessary to follow the method of FSM design, but its regarded as one of the best options.

2 Technology used

In our project, we used different equipment that use different types of technologies for different purposes to fulfil and develop the expected functionality of the car. However, there are other technologies that gives better results, but they are more expensive and difficult to get. Therefore, we used the most common used technologies in Arduino kit as LCD display 1602 or 1604, Ultrasonic sensors (HC-SR04) , H-bridge and Arduino Uno to make the project both economic and effective. In this report we will introduce each equipment used technology and how we used it to execute some purposes.

2.1 Technology of obstacle detection

In First place, we searched for detector sensor since the detection of obstacle is the most crucial part in the project, so the responsible sensor of detection should be chosen wisely. Thus, we compared many detector sensors. For example, we found out that Ultrasonic is more effective than IR sensors in our case. Therefore, we chose the Ultrasonic sensors.

2.1.1 Ultrasonic sensor HC-SR04

HC-SR04 is a sensor that is used to detect and measure the distance from an obstacle within limit range 0.02meters to 4 meters.

2.1.2 The principle of work

HC-SR04 emits ultrasonic waves at frequency of 40 kHz which propagates through the air and then reflects over the object and received by the sensor. After receiving the waves, HC-SR04 outputs the traveling time elapsed and by knowing each of the speed of Ultrasonic Waves through the air, and the time elapsed, the distance can be measured.

2.1.3 The configuration of HC-SR04

In HC-SR04 there are four pins: Gnd, Echo, Trig and Vcc. Gnd and Vcc pins are used to power the sensor and its transducer between the trig pin stands for generating and emitting the ultrasonic waves by setting it high for at least 10 s. However, these pulses will be received after reflection by the sensor. At this moment Echo pin will output the back and forth travelling time of the sensor in microseconds. We also used developed version of ultrasonic which is HC-SRF05. Where it has larger range from 2 cm to 450 cm and more precision (measurement resolution: 0.3 cm). it has the same functionality and usage as HC-SR04.

Figure 1: HC-SR04 and HC-SR05.

2.1.4 Data Sheets of HC-SR04 and HC-SR05

http://dl.behnamrobotic.com/shop/datasheet/module/module-srf05-ultrasonic.pdf
https://cdn.sparkfun.com/datasheets/Sensors/Proximity/HCSR04.pdf

2.1.5 Calculations

We calculated the distance using the physical relation of velocity and distance. Distance = (0.034*t)/2 cm. Where t stands for the time elapsed in s for back and forth travelling waves, so its divided by two. Note: the speed of the Ultrasonic waves through the air is 340 m/s or 0.034 cm/ s

2.2 Technology of displaying the results

There are various screen displays to exhibit the information to the user. For example, CRT, LCD and LED. We concluded after long search and discuss that LCD display is the best choice because its inexpensive and consume low current while it can be used instead of serial monitor in IDE. LCD is a display that shows the received information by exploiting the nature of liquid crystal

martial which align their molecules and change their polarization according to applied voltage between the transparent electrodes. —- There are many models of monochrome LCD. Some examples are 16x2 and 16x4 LCD display. Where 2 and 4 stands for the number of lines and 16 to the number of characters that can be shown in each line. We chose the appropriate model for our project which is the black 1602 LCD display.

2.2.1 LCD configuration

Gnd and Vcc pins are used to supply the LCD with power between VD is used to control the brightness of the screen. RS pin is the register between RW is a pin that set to write or read mode. En pin enables writing to the register and Pins from D0 to D7 are the 8 data pins where they are set to either high or low. Finally, the last two pins represent the anode and cathode of LED Back light. https://www.arduino.cc/en/Tutorial/HelloWorld

2.3 Motor Controlling Technology

The avoiding obstacle car will take some actions as turning to left and right or rotating around its axis or moves either in the backward or forward direction. Therefore, we need some tool to control the status of DC motor. As a result, we selected H-bridge chip as controller for DC motor. H-bridge is an integrated chip that consists of 4 MOSFET transistors to make the current follows where only two transistors activates and the rest closes leading the current to pass in different direction, and this exactly what is needed to change turning direction of the DC or Stepper motor. In this project we used L298n motor driver since its specifications satisfies our needs in this project.

3 Design Process

3.1 Equipment List

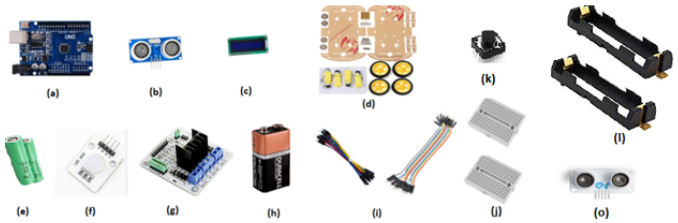

Figure 2: Equipment listl.

1. Arduino UNO R3
2. Ultrasonic sensors HC-SR04
3. LCD Display 1602
4. A set of mechanical parts of car chassis that include Four of motors, wheels, Acrylic fasteners, encoders, and M3-30 copper columns
5. Acrylic car floors, M3*7.5 screw, nuts and M3*28 screw
6. Two lithium batteries 18650
7. RGB LED
8. L298n DUAL BRIDGE DC STEPPER CONTROLLER BOARD
9. 9v battery
10. Couples of Male to Male, Female to Male and single core wires
11. Two mini-bread boards
12. Push Button
13. Two single 18650 battery holders
14. Ultrasonic sensor HC-SR0

L298n is suitable for our project where it supplies max output current from 2A

To implement this project, we followed 3 stages: The project was implemented through three phases: the mechanical design of the car, hardware implementation, testing, wires management and coding the embedded c program.

3.2 Building car chassis

We had Four of motors, wheels, Acrylic fasteners, encoders, and M3-30 copper columns 2 Acrylic car floors, M3*7.5 screw, nuts and M3*28 screw After soldiering each motor by two single core wires. After that, . We installed all the motors on the lower floor of the car (base) using M3*7.5 screw and Acrylic fasteners and for each motor, we installed an encoder We installed the M3-30 copper columns at each corner of cars base using two M3*7.5. We installed plastic base to hold the LCD Display. We installed the two 18650 batteries at the base of the car and connected them in series We installed the upper car floor using two M3*7.5 and M3*28. We installed the four wheels of the car at each corner of the car

The result of the mechanical implementation is shown in both Figures below.

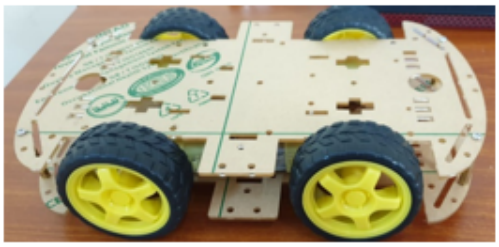

Figure 3: Car Chassis.

4 Testing Plan

We had three testing cases: Pre-implementation Testing, ultra sonic sensor Testing, then final connection Testing.

4.1 Pre-Implementation testing

1. **T**est Description: To test the initial connection, we tested the forward, back, right, and left states of the DC Motors by only connecting our 4 DC Motors to the Motor Driver and a 6v battery. Different codes were implemented to test how to run the Motors forward and backward and the sharpness of the turns in relation to the delay implied while the direction is changing.

2. **T**est steps:

   - **C**onnected the four DC Motor, with the wheels attached to the Motor, to the Motor Driver.
   - **6**V battery was connected to the Motor Driver.
   - **D**ifferent Ardunio sketches was used to test the directions.

3. **R**esults: The four states of the Motor functioned as expected and data was collected to adjust correctly the steering of the car.

4.2 Ultra Sonic sensors testing

1. **T**est Description: To test our two Ultra Sonic Sensors we designed a circuit, shown in the figure below, to test the functionality of them by connecting them alone on the robot and designing a code to calculate each sensor distance and printing on the serial monitor.

2. **T**est steps:

   - **C**onnected the two ultra sonic sensors to the Arduino and breadboard on the robot as shown in the below.
   - **d**esign a code to calculate and print the distances measured.

3. **R**esults: The two ultra sonic sensors functioned well and took measurements that represent the actual distance to any object with a short response time.

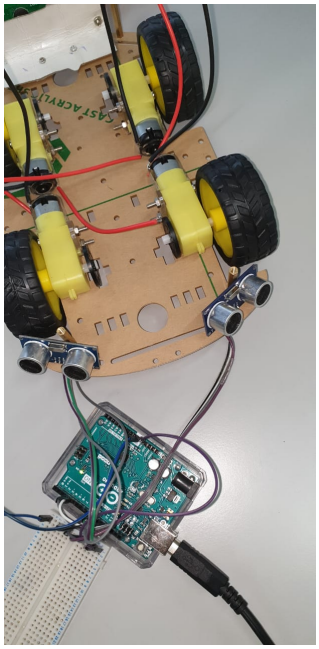

Figure 4: Ultra Sonic Test.

4.3 Final connection Testing

1. **T**est Description: After constructing our final hardware connection we tested it by implementing to it different adjusted codes and running the car across different obstacles.

2. **T**est steps:

   - **i**mplement the adjusted final code developed previously
   - **R**un the car through different obstacles

3. **R**esults: The Car was successfully in avoiding different obstacles.

5 Results and Discussion

5.1 Robot Structure and Functionality

After the connection of the wheels and motors, we figured out that the wheels are loose and because of that the car moves in a curvature, as a result we used

superglue and extra screws to install the motor without any loose; Therefore, car moves in straight line. As well as it added extra benefits in holding more weights since the car holds a lot of sensor and boards as Arduino and H-Bridge etc. We faced another problem in batteries since it discharges very fast and the location of the holders is not easy to reach; therefore, we changed its location to be reachable. As well as the ultrasonic has very slow response, so we increased the distance to recognize the obstacle before it hits it. To make it easy to calculate the distance and time elapsed, we added a push button to stop and run the motors. The nal testing results proves the avoiding obstacle car can detects the obstacles and avoid them successfully. We found some challenges in the management of the wires since a lot of sensors and modules as LCD display and motor driver have a lot of pins thus a lot of wires which make it hard to re-check the connection, so we managed in such a way to make it easier to debug the problem. The figures below show the final connections of the avoiding obstacle car.

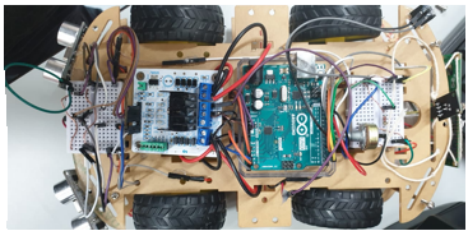

Figure 5: Final Connection.

5.2 Additional Features

Multiple Additional features were implemented in the car to distinguish it from others including a RGB, LCD, and a push-button.The RGB was added to the car as indicator for the states. For instance, when it stops, the RGB light red colour and the LCD prints stopping and when it detects an obstacle the RGB lights red colour while the LCD prints Caution!!! . When the car doesnt detect any obstacle, it keeps moving ahead while the RGB lights green colour and LCD shows ahead. Moreover, when the car detects the obstacle

on the left-hand side, the LCD shows Turn Right and when it detects it on the right hand-side it shows Turn Left. The first press of the push button is starter of the car and the second the car stops and the driven distance and the time elapsed are shown up on the LCD display.

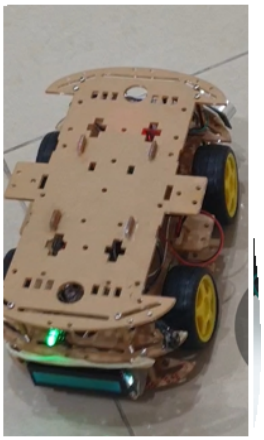

Figure 6: Final appearance.

6 Conclusion

6.1 Summary

In this course project, we build and programmed a voiding obstacle car that is controlled by the ATMEGA328 microcontroller and push button. We designed the avoiding obstacle car with RGB, LCD to show the states, and the project was designed using some approximation of the detection distance of ultrasonic to give the best result. The robot uses motor driver to control the direction of the 4 motors to turn left or right (2 wheels drive) (each two motors are connected as one motor) which provides more stability in turning, moving and tilting. The velocity of the car was set to maximum where the enable is connected to 5 volts to compete others car. Therefore, because of the maximum speed and four motors, the battery drains faster. The problem was solved temporarily but in future improvement, we will make more efforts to save the battery power by using PWM technique.

6.2 Future improvements

In the future, we will improve the efficiency of the avoiding obstacle car by changing the chassis to one that has better quality and capabilities, and we will use the PWM technique to save the usage power (battery level) where we will sit the motor to lower speed to save the over battery consumption. In the future we will use more accurate and responsive sensors instead of ultrasonic sensor to get better results in obstacle detection.

6.3 Lessons learned

We applied the knowledge of how to build an autonomous embedded system using Arduino Uno and how to use some important sensors and modules that have various applications and usage. However, we did many attempts and debugging process for ultrasonic sensors. We gain a lot of experiences in connecting modules, sensors and shields on breadboard and how to write an effective embedded c program.

7 Refrences

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https://cdn.sparkfun.com/datasheets/Sensors/Proximity/HCSR04.pdf
http://dl.behnamrobotic.com/shop/datasheet/module/module-srf05-ultrasonic.pdf
https://www.arduino.cc/en/Main/Products

8 Team work evidence

Figure 7: Team Work Evidence.