Ultrasonic Obstacle Avoidance Car

Dheeraj Skandakumar Nair
Dept of Computer Engineering
San Jose State University
San Jose, USA
dheeraj.skandakumarnair@sjsu.edu

Kevin Pham
Dept of Computer Engineering
San Jose State University
San Jose, USA
kevin.h.pham@sjsu.edu

***Abstract*—Obstacle Avoidance is the ability of any programmed device in motion to detect and avoid obstacles in its path. Obstacle can be detected by a robot using sensors such as IR sensor, Ultrasonic or Lidar sensors. In this project we are using a Tiva C Series microcontroller - TM4C123GH6PM as the processing unit of the car. The ultrasonic sensor reads the distance between the car and the obstacle in front of it and the microcontroller makes the car change its direction of motion so that it can avoid the obstacle detected in front of it. The ultrasonic sensor can detect obstacle upto 4 metres ahead. This helps to decide the path of motion of the car with minimum overheads.**

***Index Terms*—Obstacle avoidance, TM4C123GH6PM, Ultrasonic sensor**

I. Introduction

The project aims to create an Obstacle avoidance robot. Here we use ultrasonic sensors to detect obstacles and change our path as required. For this to work as intended, we want the car to be able to navigate through a small obstacle course on the ground. There will be small obstacles, and the car will need to make it from the start line to the end with minimal collisions or confusion. This will make use of the ultrasonic sensor to read what is in front of the car, and the programming will decide whether to turn left, turn right, back up, or to move forwards.

Obstacle detection and avoidance has been one of the preliminary steps while developing a robot car. We chose the idea of a self-driving car because it seems like a fun and challenging project. The car will have simple inputs and outputs, but the complexity lies in the code. The car uses an Ultrasonic sensor as the input and the output is shown through the motors that control the wheels of the car. The ultrasonic sensor measures the distance between the car and the obstacle and makes necessary decisions to avoid it and move forward. Ideally, the car will be able to go through all sorts of obstacles without crashing, but that depends on how efficient and accurate our robot is. The code will need to be simple enough to run on the microcontroller, but advanced enough that it can go through our tests.

This project is rather challenging, for it will be a combination of everything we learned so far, except this time there are no lab guides to follow. We will have to work with what we know and use our resources to discover how to build and program our proposed machine.

The general working of the robot can be summed up as follows : the ultrasonic sensor reads the data from the surroundings and sends it to the microcontroller. If an obstacle is detected, the wheels of the robot are given signals accrodingly inorder to change the course of motion and avoid the obstacle. In case of no obstacle the car moves along a straight line.

II. Equipments Required

A. The TM4C123GH6PM Microcontroller

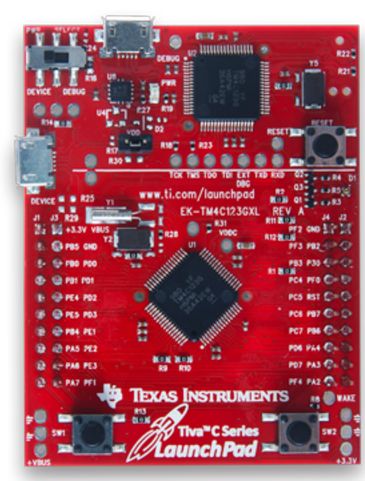

Fig. 1. TM4C123GH6PM Microcontroller

In our classes, we have been using the Texas Instruments TM4C123GH6PM board to conduct several labs. TM4C123G is a 32 bit ARM cortex M4 microcontroller developed by Texas Instruments with a broad set of peripherals. The TIVA launchpad comes equipped with a built-in processor clocking at up to 80MHz and a floating point unit (FPU). In addition, the Cortex-M4F processor supports tail-chaining. It is also equipped with a nested vector interrupt controller (NVIC). The board has been programmed using the Keil uVision5 software. During the lab classes, we have learned how to interact with the board and set up switches, leds, and general interfacing. All of this knowledge now must be combined to create our final project. The board features several GPIO pins, which will be used in our project to create an obstacle avoiding car. We need one input from the ultrasonic sensor, and two outputs to each motor wheel to drive our car. With all of these combined, we must then use the microcontroller as the “brain” of the car. It will take in values from the sensor, and make movements accordingly based on the logic that we design. There will need to be a timer interrupt to set the polling rate of our sensor, and assorted switch interrupts to start / stop the car.

B. HRC SR04 Ultrasonic Sensor

Fig. 2. HRC SR04 Utrasonic Sensor

The HC-SR04 ultrasonic distance sensor is used in this project. Providing non-contact measurements from 2cm to 400cm, this sensor has a ranging accuracy of 3mm and can measure up to 2cm. The HC-SR04 module consists of an ultrasonic transmitter, a receiver, and a control circuit.The sensor works with the simple distance forumula :

$$\text{Distance} = \text{Speed} \times \text{Time}$$

C. L298N Drive Control Module

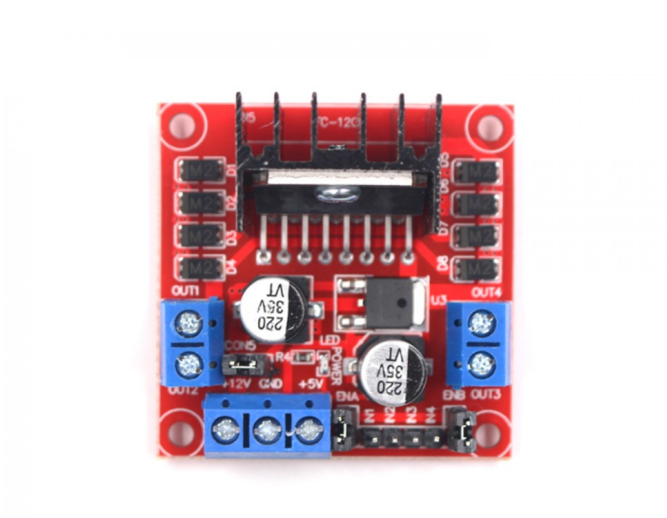

Fig. 3. HRC SR04 Utrasonic Sensor

L298N Motor Driver Module is a high power motor driver module for driving DC and Stepper Motors. This module consists of an L298 motor driver IC and a 78M05 5V regulator. L298N Module can control up to 4 DC motors, or 2 DC motors with directional and speed control.

D. 18650 3.7v Battery

The 18650 batteries are rechargeable lithium-ion batteries. They have a 3.7V voltage and capacities ranging from 1800 to 3500 mAh. The 18650 battery takes around four hours to charge on average.

Fig. 4. 18650 3.7v Battery

E. Other Components

Other components include : Breadboard, Jumper wires, 2x Wheels, Swivel wheel and Chassis.

III. Project Timeline

The timeline for this project is as follows:

- 11/20: Recieve all parts needed to begin building ✓
- 11/17: Print car chassis with SJSU Library 3d Printer ✓
- 11/22: Begin assembling car and programming ✓
- 11/27: Finish Project Deliverable 2
- 11/29: Final revisions to report, last minute demo testing and debugging

We have obtained all the components required to build the obstacle avoiding car. The chassis to hold the components of the robot was 3D printed from the SJSU library. All the parts have been assembled together and we hve begun the programming of the robot.

IV. Proposed Methodology

A. Design

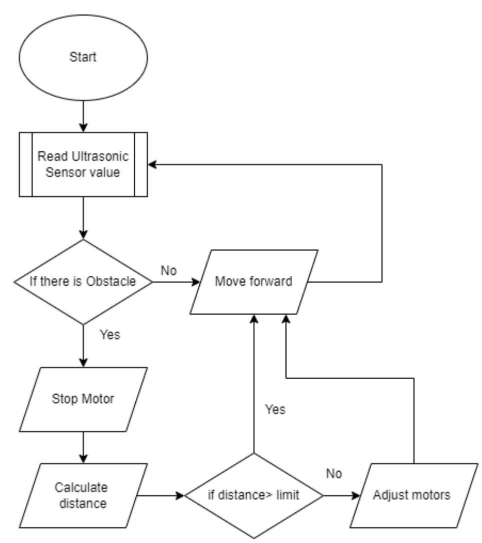

Fig. 5. Flowchart

B. Configurations

The ultrasonic sensor is mounted on top of the servo motor, which is mounted on the chassis. The dc motors are mounted on the chassis and connected to L298N motor driver. The power supply is connected to the motor driver and then 5V output is given to the board, ultrasonic sensor and servo motor. The data connections from the driver board,servo motor and ultrasonic sensor is connected to the board.

V. Implementation

The input from the ultrasonic sensor is read first and if no obstacles are detected the motors are instructed to move forward else turn the servo motor to right and left to see if we obstacles in those directions. If no obstacles are detected in those direction, then we move in that direction by manipulating the motors.

The ultrasonic sensor's ECHO and TRIG are connected to PB4 and PB6 respectively. The servo motor's data pin is connected to PA4 on the board and the inputs to the motor1 and motor2 are connected to PA2,PA3 and PA5,PA6 respectively. All the grounds are shorted together and the corresponding VCCs are shorted together. The assembly is done and code is flashed to the board and output is obtained.

VI. Outcome

Once the connections are completed and code is flashed to the board, the car runs as intended. It moves forward for a fixed time. If it detects any obstacles, it looks right and left. Based to distances measured, the logic of code decide which direction to move to.

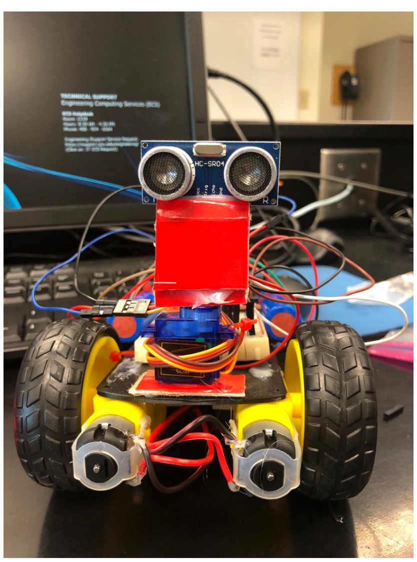

Fig. 6. The assembled car

VII. Accuracy

The robot car works as intended. It detects obstacles and if they are further than 20cm, it moves forward. If the obstacle is closer than 20cm, it looks for alternative paths on the right and left. Which ever has obstacle most further away, it moves in that direction.

The robot manages to avoid obstacles and move in a different path if it encounters any on its way.

Discussions

We chose this project due to our interest in automobiles. With Tesla, Rivian, and other automobile manufacturers moving towards smarter cars, we decided to create a smaller-scale version of it. There are many approaches to this, using a mix of sensors such as Radar, Cameras, Lasers, or in our case Ultrasonic. We chose this due to its simplicity, and uniqueness. It's also flexible and can work in a variety of applications. Other techniques such as Camera will require image recognition, which may be a bit too much for our processor, and too complex for our class. Ultrasonic works by sound waves, sending out a frequency and listening to the echo to determine the distance between the sensor and the obstacle. By sending signals back and forth, we can compute how far away the said obstacle is. Combining this with a servo allows our car to "look around", and using the wheels we can steer our car in either direction. By implementing vision and mobility to our TM4C board, we can create an obstacle avoiding vehicle, completely autonomous without user input.

The difficult part of this project lies in deciding what choice of action the car should make. Our code has to factor in what is near it and decide where to go accordingly. Depending on the course design, there may be multiple obstacles, which implies multiple outcomes that would work. The algorithm we code for the car will have to take into account which direction to turn. For our project purposes, as long as we can get to the exit it is a success. Many variables will have to be tweaked to get the car working as intended. Things that we can change to adjust our car's trajectory include: how often we scan for objects, how many degrees to turn the car, how far forward to move, how quickly to react to the environment, and the list goes on. All of these need to be factored into our code.

Another challenging part of this project was designing the chassis and wiring all components together. Luckily, many of the parts we used were found online. Amazon had parts shipped quickly, or we had parts lying around from past Arduino projects. The 3d printed chassis of our car was based on a design found on Thingiverse, except it was scaled down to fit the SJSU MLK Library's print centre. Assembling the car was through lots of hot glue and determination. The wiring, albeit messy, was the product of countless hours on pinouts and schematics of our components. Luckily, in this day and age of the internet, we can easily find documentation on all of our project parts. All that remains is programming the code to make each component work together, and the finishing touches to refine the algorithm to pass the course.

VIII. Acknowledgment

First and foremost we wish to express my wholehearted indebtedness to God Almighty for his gracious constant care and blessings showered over me for the successful completion of this project. We wish to express our profound gratitude to Assistant Professor **Dr. Nima Karimian**, who is our instructor, for the giving us this opportunity to do the project work and in making it a success. We would also like to express our deep gratitude to the Teaching Assistant **Zeel Soni** for the support and encouragement given by her to improve the project.

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