Ultrasonic Sensor devices in Semi-Autonomous Vehicles

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ABSTRACT

Fully autonomous vehicles are very expensive and complex to produce, hence the large majority of the innovative features that come with these vehicles remained inaccessible to the general public. We believe it is integral that ways to easily integrate semi-autonomous smart features in today's mass-produced vehicles is a challenge that should be researched more. This project aims to integrate a Dynamic braking system using the underestimated capability of the Ultrasound sensors and Pulse wave modulation techniques. In this context, Dynamic braking refers to the process of decelerating, accelerating and braking the vehicle relative to the distance of the object or obstacle in front of it.

To test the hypothesis that smart systems can be integrated and executed in semi-autonomous vehicles with relative ease, We created a dynamic braking system by integrating a simple dc motor, an HC-SR04 ultrasonic sensor and an Arduino Uno.

This model will act as a proof of concept project that will let us prove our hypothesis. This arrangement will mimic a dynamic system by slowing the dc motor down when an object is close to the Ultrasonic distance sensor, eventually stopping the motor completely and accelerating the motor once the object is further away.

INTRODUCTION

An autonomous car is a vehicle capable of sensing its environment and operating without human involvement. A human passenger is not required to take control of the vehicle at any time, nor is a human passenger required to be present in the vehicle at all
Ultrasonic sensors mimic echolocation used by bats, transmitting high-frequency sound waves to gauge the distance between objects within close range.

Ultrasonic sensors can be used to complement other vehicle sensors, including radar, cameras, and lidar, to get a full picture of the immediate surroundings of a vehicle. While ultrasonic sensors necessitate close proximity and slow speeds, advantages include the ability to be accurately used in situations with low visibility, such as in inclement weather conditions and dim areas.

MODULES AND METHODS

Software models and components used in this project were:

- C/C++
- Arduino libraries
- Arduino IDE
- Ultrasonic Distance Sensor HC-SR04
- Arduino Uno
- L293D motor driver IC
- DC Motor (12 volts)
- Jumper cables
- Breadboard

After integrating the hardware component coded the required instructions and set the required mathematical expressions for our project.

Distance = (Speed X time)/2

In this case, we consider the speed of sound as 343ms-1.

We then map the duration taken by the echo of the sound waves to return to the sensor to the maximum PWM value the motor can take, which is 255 in this case. (Pulse Width Modulation)

We then set the braking threshold for the motor as less than 5cm for this model, and the deceleration threshold to less than 15 cm.
Finally, we compile the code and load it onto the Arduino board and note the results.

RESULTS

Our model is able to successfully read to distances between 4 to 100 cm and modify the speed of our motor through voltage pulsing within a span of 140 ms on average. When the distance is beyond the declaration threshold, the motor is pushed to peak voltage which increases its speed and when it falls below the deceleration threshold the voltage is reduced and the speed of the motor decreases.

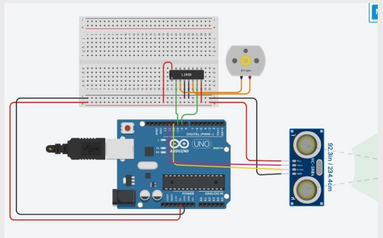

Figure 1. Our model.

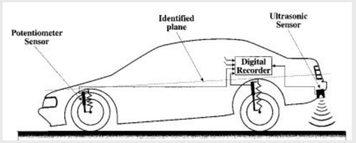

Figure 2. Alternate approach I

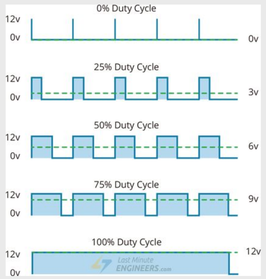

Chart 1. PWM technique in action

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15:12:09.124 -> Distance : 70 cm
15:12:09.263 -> Distance : 96 cm
15:12:09.357 -> Distance : 49 cm
15:12:09.450 -> Distance : 54 cm
15:12:09.545 -> Distance : 121 cm
15:12:09.637 -> Distance : 50 cm
15:12:09.731 -> Distance : 242 cm
15:12:09.824 -> Distance : 19 cm
15:12:09.916 -> Distance : 22 cm
15:12:10.009 -> Distance : 22 cm
15:12:10.103 -> Distance : 24 cm
```

Table 1. Output as seen by sensor

DISCUSSION

Our 2-month long project and research have shown that smart systems can be designed and implemented with relative ease for most mass-produced vehicles.

This is in contrast to popular trends in the vehicle market which reserve safety and convince features such as the dynamic braking system for expensive high end autonomous or semi-autonomous vehicles.

This study also analyzed the effectiveness of a mono-sensor based system, and found that while these systems may excel in certain scenarios in performing one task, it is best to rely on multiple sensors to accomplish the same task as it covers a wider array of data and can lead to better effectiveness of the task carried.

We believe future work could seek to integrate and test a combination of sensors and study the results.

CONCLUSIONS

A recognition for the need of this project and its necessity to prevent accidents in manned/unmanned vehicles. This project can also serve as a better addition of precaution for better driving experience on uneven terrains or unfavourable weather conditions. As ECE students, this project was significant in our understanding of the hardware and software aspects of the autonomous vehicle domain,

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