Ultrasound Sensor Data in Autonomous Vehicles

Project Exhibition Report

Submitted in partial fulfillment for the award of the degree of

Bachelor of Technology

In

Electronics and Communication (Specialization in AI & Cybernetics)

SCHOOL OF ELECTRICAL AND ELECTRONICS ENGINEERING

Submitted to

VIT BHOPAL UNIVERSITY (M. P)

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CANDIDATES' DECLARATION

We hereby declare that the Dissertation entitled "*Ultrasound Sensor Data in Autonomous Vehicles*" is our own work conducted under the supervision of Dr. Om Prakash Pahari, Assistant Professor, School of Electrical and Electronics Engineering (SEEE) at VIT University, Bhopal.

We further declare that to the best of our knowledge this report does not contain any part of work that has been submitted for the award of any degree either in this university or in other university / Deemed University without proper citation.

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Date: 09 May, 2022

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CERTIFICATE

This is to certify that the work embodied in this project report entitled **“Traffic Sign Detection in Autonomous Vehicles”** has been satisfactorily completed by **Mr. Jenish Murdia (20BAC10004), Mr. Shaun Jacob Varghese (20BAC10022), Mr. Varun Ram S (20BAC10038) & Ms. Manoshi Raha (20BAC10020)** in the School of Electrical & Electronics Engineering at VIT Bhopal University, Bhopal. This work is a bonafide piece of work, carried out under my/our guidance in the School of Electrical and Electronics Engineering for the partial fulfilment of the degree of Bachelor of Technology.

Dr. Om Prakash Pahari
Assistant Professor

Forwarded by	Approved by
Dr. Soumitra K Nayak	***Dr. Debashis Adhikari***
Program Chair	**Professor & Dean**

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Shaun Jacob

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Executive Summary

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.

List of Figures

List of Symbols & Abbreviations

AI	**Artificial Intelligence**
IEEE	**Institute of Electrical and Electronics Engineers**
DC	**Direct Current**
IC	**Integrated Circuit**
PWM	**Pulse Width Modulation**
LIDAR	**Light Detection and Ranging**

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CHAPTER 1: INTROUDCTION

1.1 MOTIVATION

Automobile crashes have become a serious safety problem, with numerous reports of property damage and fatality as a result of collisions. In cities and on roads, the number of pedestrians killed by automobiles is increasing. Automobiles frequently kill wild animals as they travel deeper into the wildlife reserves. The cost of a life cannot be calculated, and the cost of automotive damage has a negative influence on investment. Most drivers are unaware of the presence of barriers ahead, and brakes require a driver's response to operate, increasing response time and decreasing reliability. In recent years, many approaches to automotive crash avoidance systems have been presented; however, these approaches mostly focus on steering manoeuvring control. Furthermore, many systems do not take into account the automobile's safety distance to standstill, and many just send a warning signal to the driver before triggering autonomous brakes. This leaves a lot of possibility for human error.

1.2 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.

1.3 OBJECTIVE

- To create a dynamic braking system that would assist drivers in accelerating or decelerating the vehicle
- Make use of the ultrasonic distance sensor HC-SR04 to measure the distance of the object coming near to it and subsequently accelerate or decelerate the motor
- To interface the Arduino UNO board with HC-SR04 Ultrasonic distance sensor and a simple DC motor to explain our project
- To write a simple program (in C#) in order to get our sensor to working and to achieve our primary goals

1.4 METHODOLOGY – BASIC OVERVIEW

In this project, we have integrated an Ultrasonic Sensor HC-SR04 with a breadboard and Arduino UNO for our required purpose. We have used a simple DC motor to prove that as the distance from the object increases, the motor speeds and up and vice versa. This is how a Dynamic braking system is supposed to work.

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CHAPTER 2: LITERATURE SURVEY

- **Paper name -** *An Ultrasonic Sensor for Distance Measurements in Automotive Applications*
  Authors name - Allasio Casullo and Marco Parvise
  Publisher: IEEE Sensors Journal
  Date of publishing - 2 August 2001
  Summary and Findings: - This paper describes an ultrasonic sensor that is able to measure the distance from the ground of selected points of a motor vehicle. The sensor is based on the measurement of the time of flight of an ultrasonic pulse, which is reflected by the ground. A constrained optimization technique is employed to obtain reflected pulses that are easily detectable by means of a threshold comparator. Such a technique, which takes the frequency response of the ultrasonic transducers into account, allows a sub-wavelength detection to be obtained. The sensor is composed of only low-cost components, thus being apt for first car equipment in many cases, and is able to self-adapt to different conditions in order to give the best results.

- **Paper name -** *Evaluation of a Bicycle-Mounted Ultrasonic Distance Sensor for Monitoring Road Surface Conditions*
  Authors name - Yoshiaki Taniguchi; Kodai Nishii; Hiroyuki Hisamatsu
  Publisher: IEEE
  Date of publishing - 3rd June 2015
  Summary and Findings: - We investigate using a low-cost ultrasonic distance sensor mounted on a bicycle to monitor the road surface conditions in the front region in this article. We use an off-the-shelf node Arduino, an ultrasonic distance sensor, and a standard bicycle to build and construct a road surface condition monitoring system. The ultrasonic distance sensor is shielded by a plastic shield plate in the implemented system to restrict the detecting zone. We show that the monitoring system can identify a 223 cm distant object on the road in the front region of a moving bicycle through experimental assessments.

CHAPTER 3: PROBLEM FORMULATION AND DETAILED METHODOLOGY

3.1 PROBLEM FORMULATION

- **Problem Statement**
    - **Problem Definition:** Agent is in motion; agent arrives at a path with obstacle vehicle. Agent will only be lawful if it slows down and takes necessary action.
    - **Problem Limitation:** Agent must be able to detect and differentiate dynamic distance between itself and the object and also give an alert according to the detected information.
- **Problem Solution:** Detect and measure distance from obstacle, and take necessary action to stay lawful
- **Solution Space:** There are multiple possibilities to choose from

Operators: agent can speed up or slow down to specific values or even completely stop, default value of motion is 30 units

3.2 LIST OF COMPONENTS USED

Software Modules and Hardware Components used in the Project were:

- C/C++
- Arduino libraries
- Integrated Development Environment
- Ultrasonic Distance Sensor HC-SR04
- Arduino UNO
- L293D Motor Driver IC
- DC Motor (12 V)
- Jumper Wires
- Breadboard

3.3 DETAILED METHODOLOGY

- After integrating the hardware component coded the required instructions and set the required mathematical expressions for our project i.e., Distance = (Speed X time)/2. Our arrangement should look like something shown in Fig. 3.1
- In this case, we consider the speed of sound as $343ms^{-1}$.

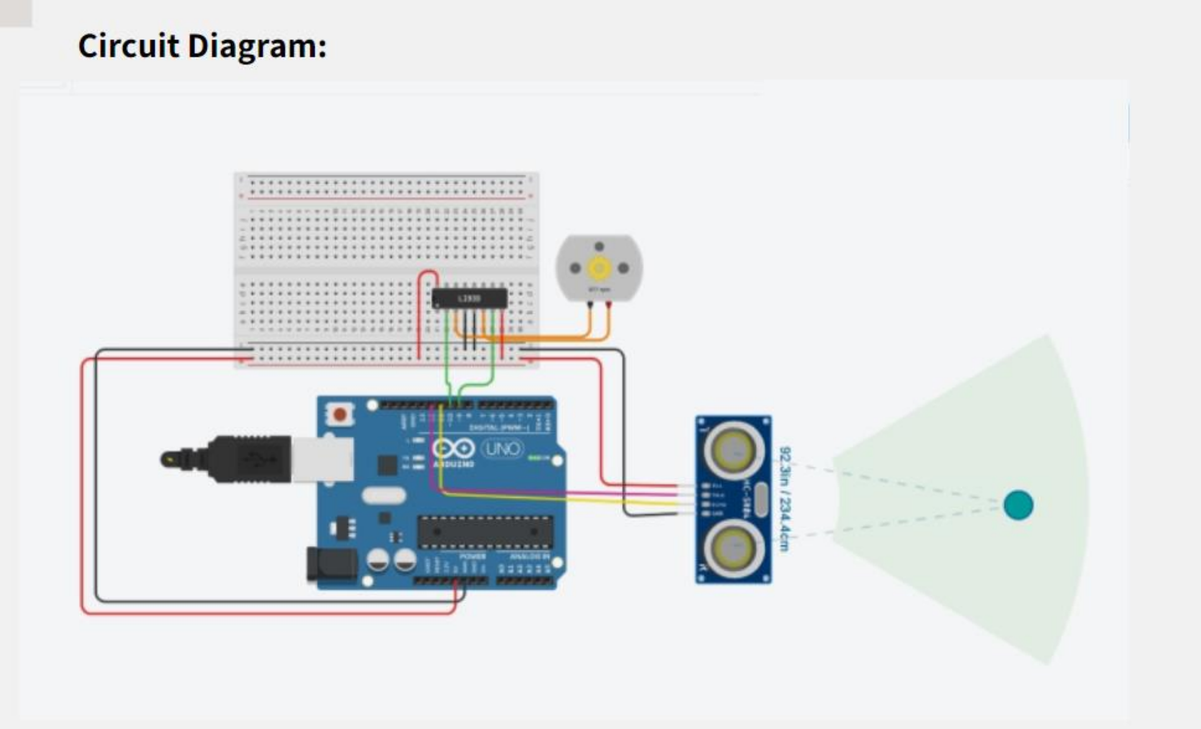

Fig. 3.1 Circuit Diagram

- We then map the duration taken by the echo of the sound waves to return to the sensor to the maximum PWM (Pulse Width Modulation) value the motor can take, which is 255 in this case. Fig. 3.2 can explain Pulse Width Modulation better.

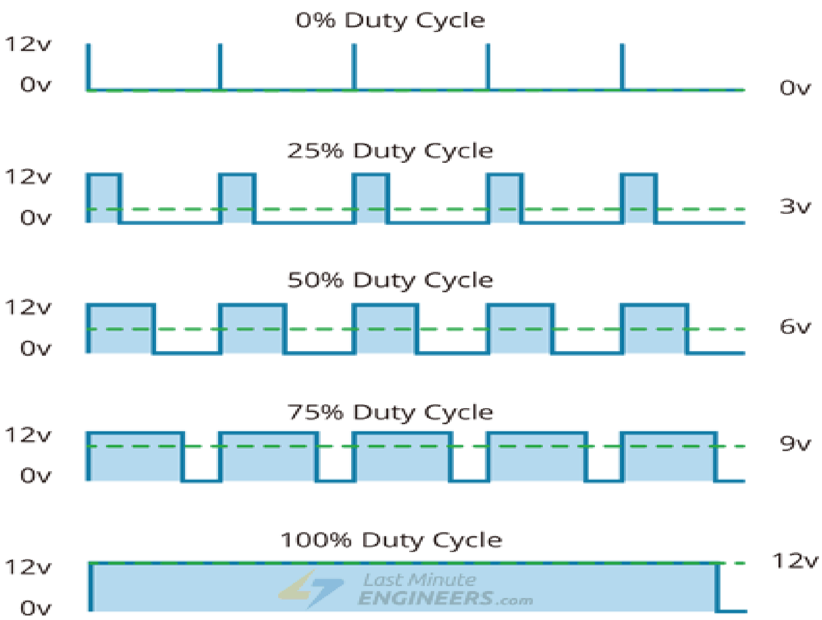

Fig. 3.2 Pulse Width Modulation (PWM)

- 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

CHAPTER 4: TECHNICAL IMPLEMENTATION

This is the Code that we have written for our model:

```
//Sensor info 100-19000 sensor data min-max

const int trigPin = 12;

const int echoPin = 11;

long duration;

int distanceCm;


// Motor A connections

int enA = 5;

int in1 = 10;

int in2 = 9;


void setup()

 {

  // Set all the motor control pins to outputs

  pinMode(enA, OUTPUT);

  pinMode(in1, OUTPUT);

  pinMode(in2, OUTPUT);


  // pinmode of SCH-04 sensor

  Serial.begin(9600);
```

```
  pinMode(trigPin, OUTPUT);
  pinMode(echoPin, INPUT);

  // Turn off motors - Initial state
  digitalWrite(in1, LOW);
  digitalWrite(in2, LOW);

  //initialize communication with console
  Serial.begin(9600);
  delay(100);

}

void loop()
{

  speedControl();
  delay(10);


  //read DISTANCE from Sensor
  delay(80);    //delay new cycle sensor reading
  digitalWrite(trigPin, LOW);
  delayMicroseconds(2);
  digitalWrite(trigPin, HIGH);
  delayMicroseconds(10);
  digitalWrite(trigPin, LOW);
```

```
  duration = pulseIn(echoPin, HIGH);   //EchoPin signal timing - ms
  distanceCm = duration*0.034/2;      // Distance calculation in CM

  //Serial.print the distance & duration
  Serial.print("Distance : " );
  Serial.print(distanceCm);
  Serial.println(" cm ");

}

//Motor speed control based on "distanceCm"
void speedControl()
 {
  // Turn on motors
  digitalWrite(in1, LOW);
  digitalWrite(in2, HIGH);

  if((distanceCm<=5))
    {
digitalWrite(in1, LOW);
digitalWrite(in2 , LOW);

delay(25);
}

 if((distanceCm>=25))
```

```
  {
analogWrite(enA, 255);
delay(25);
}
else
{
analogWrite(enA, 100);
delay(25);
  }
 }
```

CHAPTER 5: RESULTS AND DISCUSSION

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.

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 analysed 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.

```
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
15:12:10.195 -> Distance : 18 cm
15:12:10.288 -> Distance : 16 cm
15:12:10.381 -> Distance : 14 cm
15:12:10.475 -> Distance : 15 cm
15:12:10.569 -> Distance : 17 cm
15:12:10.663 -> Distance : 81 cm
15:12:10.803 -> Distance : 144 cm
15:12:10.896 -> Distance : 77 cm
15:12:10.989 -> Distance : 17 cm
```

Fig. 5.1 Output shown on screen

CHAPTER 6: CONCLUSION AND FUTURE SCOPE

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. Our idea, being capable of working on autonomous vehicles, also lessens the human workload as soon it would not be necessary for humans to drive manually at all.

Coming to future scope, we would like to point out that we can implement our ideas in autonomous car giants like Google and Tesla, however our idea does not intend to replace the existing LIDAR that is used to autonomous vehicles. We only intend to make our model work in addition to LIDAR. In the near future, we also intend to bring down the statistics of road and driving related incidents with our model.

The alternate approach to our model is shown in Figure 6.1.

We must also comprehend India's autonomous vehicle requirements. Indian roadways are notorious for being clogged with traffic, resulting in extremely congested roads. The frequency of vehicle accidents and the number of people killed in them is increasing at an alarming rate.

These are the few primary problem areas where autonomous vehicles can make a significant difference.

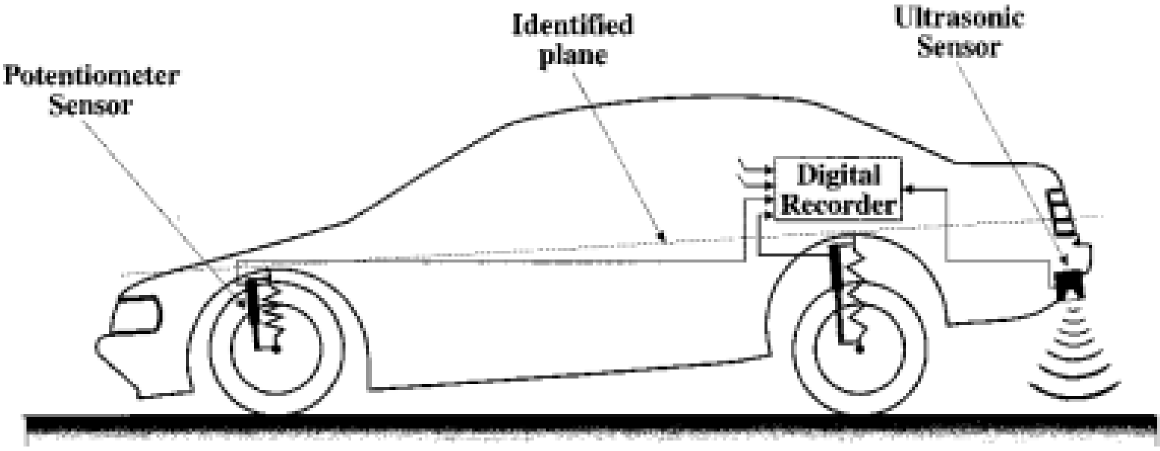

Fig. 6.1 alternate approach

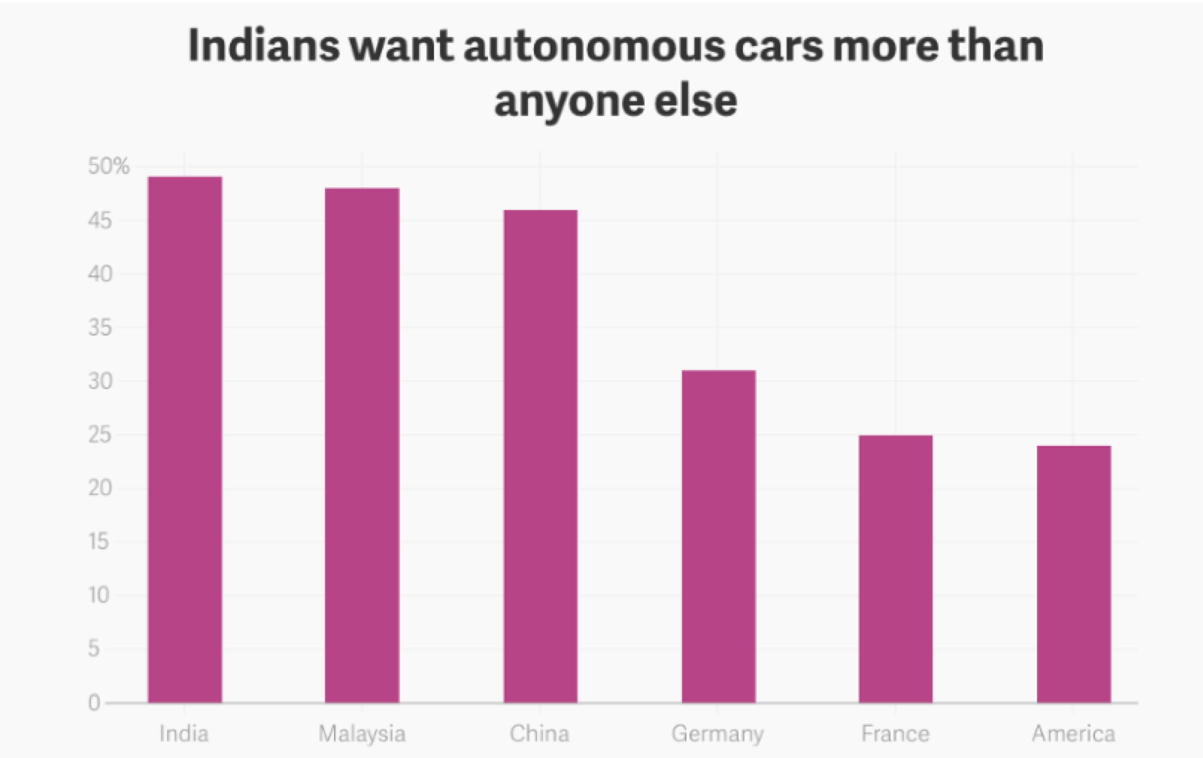

Fig. 6.2 Graph showing Indian demand for autonomous cars

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APPENDIX-I

(Description of few components used)

- **HC-SR04 sensor**: The HC-SR04 Ultrasonic Distance Sensor is a sensor used for detecting the distance to an object using sonar. It's ideal for any robotics projects one has which requires one to avoid objects, by detecting how close they are you can steer away from them.

- **Arduino UNO:** Arduino UNO is a microcontroller board based on the ATmega328P. It has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz ceramic resonator, a USB connection, a power jack, an ICSP header and a reset button. It contains everything needed to support the microcontroller.

- **L293D motor driver:** The L293D is a popular 16-Pin Motor Driver IC. As the name suggests it is mainly used to drive motors. A single L293D IC is capable of running two DC motors at the same time; also, the direction of these two motors can be controlled independently.

- **DC Motor:** An electric motor operated by DC (direct current) is known as a DC motor. A DC motor converts DC electrical energy into mechanical energy.

- **Breadboard:** A breadboard is a solderless device for temporary prototype with electronics and test circuit designs.