Design and Fabrication of an Automatic Breaking System Using Ultrasonic Sensors

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***Abstract*—** Road safety and vehicle automation are critical areas of focus in modern engineering. This project presents the development of a small-scale prototype of an **Design and Fabrication of an Automatic Breaking System Using Ultrasonic Sensors** , designed to detect and respond to obstacles in its path using low-cost sensors and microcontroller-based logic. The system utilizes **two ultrasonic sensors** positioned at the front of the vehicle to continuously monitor the surroundings and measure the distance of approaching obstacles. When an object is detected within a predefined safe distance, the system automatically stops the vehicle using the **L293D motor driver**, simulating an auto-braking mechanism. Additionally, a **buzzer** is activated to provide an audible warning to indicate the presence of an obstacle. The core of the system is controlled by an **Arduino Uno**, which processes sensor data and makes real-time movement decisions. This prototype demonstrates how basic embedded systems and sensors can be integrated to create a functional, cost-effective safety feature, highlighting its potential application in smart vehicles and autonomous navigation systems.

Keywords— Automatic Breaking System, Ultrasonic Sensor, Obstacle Detection, Collision Avoidance, Microcontroller, Vehicle Safety, Embedded System, Accident Prevention, etc.

I. INTRODUCTION

Robotics, as a multidisciplinary domain, blends mechanical engineering, electronics, computer science, and artificial intelligence to design machines capable of performing tasks with varying levels of autonomy. In recent decades, the evolution of robotics has transitioned from fixed industrial arms performing repetitive tasks to **mobile autonomous robots** capable of navigating complex and dynamic environments. One of the most vital aspects of mobile robotics is **obstacle avoidance**—the capability of a robot to detect, evaluate, and respond to obstacles in its path without human intervention.

Without effective obstacle avoidance, mobile robots would struggle in real-world environments, where unpredictability is the norm. Whether navigating a factory floor, an urban street, or a domestic living room, robots must constantly assess their surroundings and adapt their behavior to avoid collisions. This capability is not only essential for task efficiency but also for the safety of both the robot and nearby humans or objects.

Historical Context of Obstacle Detection :

Historically,obstacle avoidance mechanisms were rudimentary. Early robots were often restricted to pre-defined paths or environments that were free of obstacles. Collision detection was achieved through basic **mechanical bumpers** or **limit switches**—physical sensors that responded when the robot made contact with an object. These systems were reactive, only informing the robot of an obstacle *after* contact had occurred, which posed significant limitations in delicate or hazardous environments.

As robotics evolved, engineers began to explore more proactive methods of obstacle detection. The 1980s and 1990s saw the integration of **infrared (IR) sensors**, which allowed robots to detect objects based on reflected infrared light. While more advanced than bumpers, IR sensors were limited in range and susceptible to interference from ambient light.

This limitation gave rise to the incorporation of **ultrasonic sensors**, which use sound waves to detect obstacles. These sensors could detect objects without physical contact, worked in both light and dark conditions, and offered greater range and reliability. With further advancements in microprocessors and digital control systems, ultrasonic sensors became a standard in many autonomous robotic applications.

Principle of Ultrasonic Obstacle Detection:

Ultrasonic sensors work on the principle of **echolocation**, similar to how bats or dolphins navigate. These sensors emit high-frequency sound waves (typically around 40 kHz) and measure the time taken for the echo to return after bouncing off an object. This **time-of-flight (ToF)** measurement allows the system to calculate the distance to the obstacle using the speed of sound in air. The basic formula used is:

$$\text{Distance} = \frac{\text{Speed of Sound} \times \text{Time}}{2}$$

The division by 2 accounts for the round trip of the sound wave (from sensor to obstacle and back). This method provides real-time data, allowing the control system to make quick decisions about speed adjustments, direction changes, or braking.

Due to their cost-effectiveness and ease of integration with microcontrollers like the **Arduino Uno**, ultrasonic sensors have become a common choice in academic projects, prototypes, and even commercial robotic platforms.

Modern Obstacle Avoidance Technologies: While ultrasonic sensors remain popular, modern robotics increasingly employs more sophisticated technologies such as:

- **Infrared Sensors**: Useful for short-range detection but affected by ambient light.
- **LiDAR (Light Detection and Ranging)**: Provides high resolution 2D or 3D mapping; widely used in autonomous vehicles but costly.
- **Computer Vision (CV)**: Uses cameras and AI algorithms to visually interpret the environment; capable of object recognition and tracking.
- **Radar**: Effective in various weather conditions; often used in automotive obstacle detection.

Each technology comes with trade-offs in terms of **cost, complexity, power consumption, accuracy**, and **processing requirements**. For low-budget or educational projects, ultrasonic sensors strike a balance between affordability and performance, making them an ideal choice for demonstrating basic obstacle avoidance and auto-braking concepts.

Significance of Obstacle Avoidance in Robotics : Obstacle avoidance is more than a technical function—it is a **fundamental enabler** of autonomy. It allows mobile robots to operate in **unknown, unstructured**, or **dynamically changing environments**. Whether a robot is delivering medicine in a hospital, exploring terrain on Mars, or cleaning a living room floor, it must navigate safely and efficiently.Key reasons obstacle avoidance is so important include:

- **Safety**: Prevents damage to the robot, surrounding objects, and humans.
- **Efficiency**: Reduces interruptions in operation due to collisions.
- **Autonomy**: Enables robots to operate independently without continuous monitoring.
- **Adaptability**: Allows robots to function in environments not pre-programmed or mapped in advance.

Moreover, as we transition into the era of **smart mobility** and **intelligent transportation**, the same principles of obstacle avoidance are being adopted in **automated braking systems, driver assistance systems**, and **fully autonomous vehicles**. These applications aim to reduce traffic accidents and improve road safety by removing or reducing the chance of human error.

Relevance to This Project The project titled **"Obstacle Avoidance and Auto Braking System Vehicle using Two Ultrasonic Sensors, Buzzer, and L293D Motor Driver"** aims to demonstrate a simplified model of what is being implemented in high-end smart vehicles. By integrating **ultrasonic sensors** with an **Arduino-based control system**, the project replicates how a vehicle can sense nearby obstacles and make **real-time decisions** to stop or reroute.
In this project:

- The ultrasonic sensors serve as the "eyes" of the vehicle.
- The Arduino processes sensor data and acts as the "brain."
- The L293D motor driver controls the "legs" (motors) of the vehicle.
- The buzzer provides an "audible warning" system to mimic in-vehicle alerts.

This simplified model not only illustrates how obstacle detection works but also introduces learners to real-world engineering concepts like **sensor integration, control systems, and embedded programming**.

It also highlights the growing importance of safety features in vehicles, particularly **auto-braking systems**, which are becoming a standard in modern automotive design.

II. Problem Identification

In today's world, road accidents are one of the major causes of injury and death. A large number of these accidents occur due to human error, such as slow reaction time, distraction, or failure to notice nearby obstacles — especially while driving at low speeds, reversing, or parking.

To minimize such accidents, there is a strong need for an automatic braking system that can detect obstacles and apply brakes automatically before a collision occurs.

Currently, most advanced braking systems (like those in luxury vehicles) use expensive technologies such as radar or LiDAR, which are not affordable or practical for small or low-cost vehicles. Therefore, developing a low-cost and reliable automatic braking system using ultrasonic sensors can help improve vehicle safety and reduce accidents.

This project aims to design and fabricate such a system by using ultrasonic sensors to measure the distance between the vehicle and an obstacle. When the object is detected within a set distance, the system automatically applies the brakes to prevent collision.

- Problem: Increasing road accidents due to human error and delayed driver reaction.
- Cause: Lack of low-cost automatic braking systems in normal vehicles.
- Need: An affordable system that can detect nearby obstacles and automatically apply brakes.
- Solution: Design and fabrication of an automatic braking.

III. Literature Reviews

A) Literature Survey:

In order to place your project in context, this chapter reviews prior work in obstacle avoidance, auto braking, and related robotics systems.

The aim is to understand the methodologies, strengths, and limitations of similar projects, and then to identify how your design can improve upon them.

The literature surveyed includes academic journal papers, conference articles, and student/DIY robotics projects that use ultrasonic sensors, motor drivers (like L293D), and embedded controllers such as Arduino or equivalents.

Review of Similar Projects or Techniques. Below are several past works relevant to your project, with focus on their approach, components used, and how they handled obstacle detection, avoidance, and automatic stopping.

Techniques and Algorithms from Literature

- From these surveyed works, several techniques and algorithms are commonly used:

- **Threshold-based detection**: If ultrasonic sensor reports distance less than some threshold, the robot performs avoidance or stopping. Simple, low overhead.

- **Multiple sensor fusion**: Use of two or more sensors arranged across front or sides to widen the detection field and reduce blind spots. Helps better decision.

- **Real-time data processing**: Filtering of sensor data to reduce noise; averaging multiple readings; some use median filtering.

- **Reactive vs predictive behavior**: Most projects are reactive (respond only after obstacle is detected). A few include predictive or smarter strategies, like using ML to predict obstacle proximity or direction.

- **Alert mechanisms**: Some projects include warning indicators (e.g., buzzer or LEDs), while many focus only on motor control.

- **Motor control / driver usage**: L293D is common; motor shield driver; some projects use more powerful drivers depending on motor needs.

1. Obstacle Avoidance Robot Using Arduino by Pavithra A.C. & Subramanya Goutham V (2018) – IJERT

In this study, the authors developed an obstacle avoidance robot using an Arduino microcontroller (ATmega328), ultrasonic sensors, and a motor driver (L293D or motor shield). The system operates by detecting obstacles through the ultrasonic sensors. When an obstacle is identified, the microcontroller commands the motors to redirect the robot, either by turning or moving in an alternate direction to prevent a collision. The approach is simple and cost-effective, utilizing readily available components suitable for indoor and low-speed operations. However, the limitation of this system is the absence of an automatic braking feature, and it mainly focuses on reactive avoidance. It may also struggle with dynamic or high-speed obstacles.

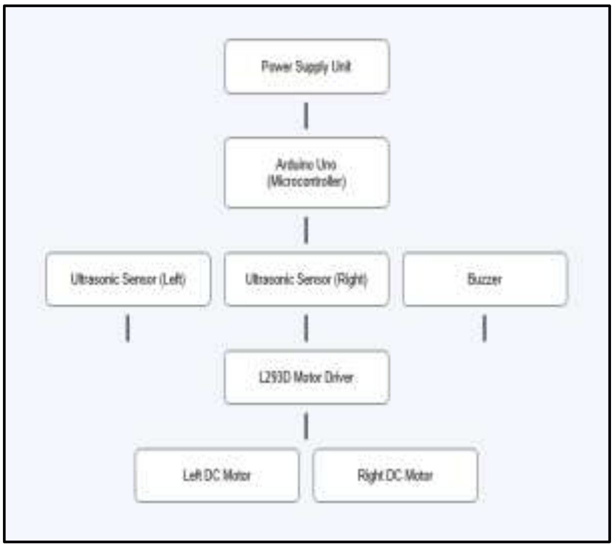
2. Obstacle Avoiding Robotic Vehicle with Arduino and Ultrasonic Sensor (Vignan's Foundation) – ScienceScholar

This work presents an obstacle avoiding robotic vehicle that employs ultrasonic and proximity sensors integrated with an Arduino microcontroller and DC motors. The robot continuously senses its environment and detects obstacles in its path. When an obstacle is detected, it takes an alternate route and resumes motion once the path is clear. The control algorithm is based on sensor thresholding to make avoidance decisions. This system effectively demonstrates basic obstacle avoidance and is reliable in static obstacle conditions, making it useful for navigation in unknown environments. However, it lacks an automatic braking or stopping mechanism and has limited sensor coverage, reducing its performance in dynamic or fast-changing environments.

3. Obstacle Avoidance Robot: A Review by Bharti et al. (2022) – IJRASET

Bharti and colleagues provided a comprehensive review of multiple obstacle avoidance robot designs. The reviewed works typically utilize ultrasonic sensors and Arduino microcontrollers, while some incorporate multiple sensors for a broader detection field or even vision-based techniques. The review analyzes various aspects such as sensor arrangement, avoidance logic, detection range, and reaction time. It highlights that the use of multiple sensors and advanced algorithms significantly improves system robustness and reliability. Nevertheless, many designs reviewed lack an effective braking mechanism or warning system and are generally limited to low-speed, controlled environments.

4. Obstacle Detection and Avoidance Using Ultrasonic



Sensors in Autonomous Robots by Jiajun Ma – OUCI

In this research, multiple ultrasonic sensors were used for real-time distance measurement, with control typically implemented on Arduino or a similar microcontroller platform. The study compares single-sensor and multi-sensor setups, focusing on threshold-based avoidance and path adjustment techniques. Noise filtering algorithms were also employed to enhance reliability. The system demonstrated good accuracy and robustness under various conditions, with the multiple-sensor configuration providing a wider field of detection. However, the design did not include an explicit auto-braking feature, and the response time may lag in fast-moving obstacle situations. Moreover, most experiments were conducted in controlled laboratory environments with static obstacles.

B) Literature Summary

From the literature, it is clear that obstacle avoidance is a well-studied area, with many projects using ultrasonic sensors and Arduino-based platforms. However, many of these focus solely on avoidance, with less emphasis on automatic braking or warning systems. Your project fills in this niche by combining obstacle avoidance with auto-braking and audible warning, using a minimal number of sensors and affordable hardware.

This literature survey helps you define the criteria for evaluating your project (such as reaction time, stopping distance, reliability, cost) and informs design decisions (sensor placement, threshold values, motor control logic, etc.).

C) Research Gap

- **Lack of auto-braking/stopping**: Many obstacle avoidance robots steer away but do not implement a full stop or emergency brake in close obstacle conditions.
- **Limited sensor arrangement**: Single frontal sensors leave blind spots; side/back detection is less common.
- **Warning systems**: Fewer projects include alert mechanisms (buzzers, alarms) especially combined with braking.
- **Dynamic / high-speed environments**: Most systems are tested in slow or static setups; performance may degrade with moving obstacles or at increased speed.
- **Complexity vs cost tradeoff**: More sensors, or use of ML, increase cost, processing load, and energy usage.
- **Lack of standard benchmarking**: Different works use different thresholds, speeds, and environments, making comparison difficult.

IV. Research Methodology

A. Proposed System

Fig. 1. Block Diagram

Working:

This chapter explains the real-time functioning of the robot during operation, covering how each hardware component contributes to its ability to detect obstacles, make movement decisions, and activate warnings. The robot operates autonomously using sensor feedback and embedded logic implemented via an Arduino microcontroller.

Step 1: Power ON and Initialization

The system is powered using a battery pack connected to both the Arduino and the L293D motor driver.

The Arduino Uno initializes all necessary pins (sensor triggers and echoes, motor controls, buzzer).

Motors and sensors are set to their default idle states (no motion or sound yet).

Step 2: Distance Sensing Using Ultrasonic Sensors

The two **HC-SR04 ultrasonic sensors** (mounted on the left and right front sides) are triggered one after the other.

Each sensor emits a 40 kHz ultrasonic sound wave through its TRIG pin.

The wave travels until it hits an object and reflects back.

The ECHO pin receives the reflected signal, and the Arduino calculates the time difference to determine the distance using the formula:

$$\text{Distance (cm)} = \frac{\text{Time } (\mu\text{s}) \times 0.0343}{2}$$

Both sensor distances are read multiple times in a loop for improved accuracy.

Step 3: Obstacle Detection Logic

After both distances are calculated, the robot compares the values against a preset threshold (e.g., 15 cm). This threshold determines whether an obstacle is "too close" and a reaction is needed.

Three main scenarios:
No Obstacle Detected
Left and right distances > threshold (e.g., >15 cm)
→ Action: Both motors run forward. The robot continues in a straight line.
→ Buzzer: OFF
Obstacle on One Side Only
One sensor detects <15 cm, the other >15 cm
→ Action: Robot turns away from obstacle. If obstacle is on left, robot turns right
If obstacle is on right, robot turns left
→ Buzzer: OFF
Obstacle on Both Sides or Very Close Both left and right distances < threshold
→ Action: Stop all motors.
→ Buzzer: ON to alert that braking has been activated

Fig.2. Model

V .APPLICATIONS

Obstacle avoidance is a fundamental function in robotics and autonomous systems. The design and working principle of the prototype robot presented in this project have several real-world applications across various domains. The same core logic—

Below are key application areas where obstacle avoidance systems are critical:

While full-fledged autonomous cars use advanced systems like **LiDAR**, **cameras**, and **AI**, the **core principle of obstacle detection and response** remains the same:

- **Detect** nearby vehicles, pedestrians, or objects
- **Decide** whether to brake, swerve, or continue
- **Act** in real-time to ensure safety

Our robot applies this principle at a basic level, showcasing how a simple ultrasonic-based system can serve as a foundation for more complex autonomous vehicle systems.

VI. ADVANTAGES

- Saves space and simplifies wiring
- Reduces need for multiple power adapters or batteries
- Efficient (less heat than linear regulators like 7805)
- Supports simultaneous multi-voltage use

VII. LIMITATIONS

- Threshold-based detection: If ultrasonic sensor reports distance less than some threshold, the robot performs avoidance or stopping. Simple, low overhead.
- Multiple sensor fusion: Use of two or more sensors arranged across front or sides to widen the detection field and reduce blind spots. Helps better decision.
- Real-time data processing: Filtering of sensor data to reduce noise; averaging multiple readings; some use median filtering.
- Reactive vs predictive behavior: Most projects are reactive (respond only after obstacle is detected). A few include predictive or smarter strategies, like using ML to predict obstacle proximity or direction.
- Alert mechanisms: Some projects include warning indicators (e.g., buzzer or LEDs), while many focus only on motor control.
- Motor control / driver usage: L293D is common; motor shield driver; some projects use more powerful drivers depending on motor needs.

VIII. RESULT

This chapter summarizes the practical results of the robot prototype, observations from testing, and limitations identified during real-world operation. It also includes visual documentation of the working model.

Output Demonstration :- After uploading the code to the Arduino Uno and completing the hardware assembly, the robot was powered using a 9V or 12V battery pack. The robot performed as expected in various test environments such as open rooms, narrow hallways, and controlled obstacle courses.

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Demonstrated Functionalities:

Test Case	Expected Behavior	Observed Result
Clear path ahead	Robot moves forward continuously	Successful
Obstacle detected on left side	Robot turns right	Successful
Obstacle detected on right side	Robot turns left	Successful
Obstacles on both sides (≤ 15 cm)	Robot stops and buzzer turns on	Successful
Obstacle removed after stop	Robot resumes forward movement and buzzer turns off	Successful

Table nu. 1

IX. Conclusion

This project focused on designing and implementing an **Obstacle Avoidance and Auto Braking System Vehicle** utilizing two ultrasonic sensors, a buzzer, an L293D motor driver, and an Arduino microcontroller. The primary goal was to enable the robot to autonomously detect obstacles and take appropriate actions such as turning away or stopping with an audible alert to prevent collisions.

Throughout the project, we successfully integrated hardware components and developed control algorithms that allowed the robot to:

- Continuously sense its environment using ultrasonic sensors,
- Process sensor data in real-time with the Arduino,
- Control motor directions via the L293D driver for movement and turning,
- Activate a buzzer to alert when obstacles are dangerously close.

This hands-on experience provided valuable insights into the principles of sensor-based navigation, motor control, and embedded programming. We learned how to interpret sensor data, implement conditional logic for decision-making, and manage power and connectivity among components.
The project was effective in demonstrating a basic yet functional model of autonomous obstacle avoidance and braking. It highlights the potential for using low-cost sensors and simple control logic to develop intelligent robotic behaviors. However, we also identified limitations such as restricted sensing angles and the absence of advanced navigation features, which can be addressed in future work.
Overall, this project serves as a foundational step toward more sophisticated autonomous systems and deepens understanding of robotics concepts that are applicable across industrial, commercial, and research domains.

X. Future Works

While the current robot successfully demonstrates basic obstacle avoidance using ultrasonic sensors and a microcontroller, there is significant potential for further development. By incorporating additional sensors, artificial intelligence, and navigation technologies, the robot can evolve into a highly capable autonomous system.

Below are key areas for future improvement and expansion:

Integration of Advanced Sensors

The current system uses only two **ultrasonic sensors**, which limits detection range and angle. In future versions, additional and more sophisticated sensors can be used to enhance environmental awareness:

- Infrared (IR) Sensors: Useful for short-range detection and edge or line following.
- LiDAR (Light Detection and Ranging): Offers 360° high-resolution mapping of the surroundings. Used in autonomous vehicles and drones.
- Proximity and Bumper Sensors: Add tactile feedback for close-range object interaction.
- Camera Modules: Enable basic image recognition, object tracking, or visual navigation.

By fusing data from multiple sensor types, the robot can perform **sensor fusion**, which improves accuracy and reliability in dynamic environments.

Use of AI and Machine Learning
Implementing Artificial Intelligence (AI) or Machine Learning (ML) algorithms can make the robot significantly smarter and adaptable:

- Reinforcement Learning: Enables the robot to learn from its environment and improve over time.
- Object Classification: Allows the robot to distinguish between different types of obstacles and respond accordingly (e.g., avoiding people but approaching objects).
- Behavioral Modelling: AI can help mimic human-like decision-making or customize navigation strategies for different scenarios.

This would require more powerful hardware, such as a Raspberry Pi, NVIDIA Jetson, or cloud-based processing.

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