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Automatic Braking System

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ABSTRACT—

The increasing number of road accidents due to delayed human response has necessitated the development of advanced driver-assistance systems (ADAS). One such innovation is the Automatic Braking System (ABS), designed to enhance road safety by reducing reaction time and mitigating collisions. This project presents the design and implementation of a prototype automatic braking system using Arduino Uno, ultrasonic sensors, and electronic relays. The system detects obstacles in real-time and activates braking without human input, thereby decreasing the total stopping distance. Experimental results from a scaled model demonstrate the system's effectiveness, with the vehicle coming to a halt safely upon obstacle detection. The findings support the integration of such systems in vehicles to prevent accidents, especially in urban environments and congested traffic.

Keywords— Automatic Braking System (ABS), Vehicle Safety, Arduino, Ultrasonic Sensors, Collision Detection, Road Accident Prevention, Autonomous Vehicles, Braking Distance, Real-time Obstacle Detection, Prototype Design.

Introduction

1.1 General Information

In recent years, the automotive industry has witnessed a paradigm shift towards safety and automation. Road traffic accidents, often caused by delayed driver reactions, remain a major public safety concern worldwide. As a solution, advanced driver-assistance systems (ADAS) have gained traction. Among them, the Automatic Braking System (ABS) stands out for its capability to automatically halt a vehicle upon detecting a potential collision, significantly reducing accident severity.

1.2 Aim

This project aims to design and develop a working model of an Automatic Braking System using an Arduino microcontroller and ultrasonic sensors. The system is intended to detect obstacles in real time and activate braking mechanisms without requiring manual intervention.

1.3 Scope of Work

The scope of this research includes designing a prototype vehicle equipped with sensors and actuators, developing logic for collision avoidance, calculating stopping distances, and evaluating system performance in various simulated scenarios. The system's effectiveness in reducing reaction time and stopping distance is analyzed using theoretical and experimental data.

1.4 Justification

With the increasing number of vehicles and congested roads, the margin for driver error continues to shrink. Human reaction time often falls short in emergency situations, leading to avoidable accidents. Implementing automatic braking technology offers a proactive approach to road safety. This project provides a cost-effective, scalable, and reliable solution that can be integrated into future autonomous and semi-autonomous vehicles.

Related Work

. The evolution of vehicle safety mechanisms has led to significant developments in automated systems, particularly the Automatic Braking System (ABS). Anderson et al. (2010) were among the first to highlight how ABS can minimize accident rates by providing faster-than-human response during critical driving scenarios. Their findings emphasized the role of early collision detection in enhancing vehicular safety.

Further studies by Lee and Abdel-Aty (2015) confirmed that vehicles equipped with advanced driver-assistance systems (ADAS), including ABS, show a marked reduction in rear-end collisions. These systems utilize a combination of sensors and algorithms to assess and react to dynamic driving conditions more effectively than manual control.

Research conducted by Schmidt and Färber (2017) delved into the integration of radar and camera-based sensors, emphasizing that multi-sensor setups enhance the accuracy and reliability of automatic braking responses. The combination of hardware and intelligent software significantly reduces false positives, a major limitation in early ABS models.

Zhao et al. (2019) explored the application of machine learning to improve ABS responsiveness. By training models on traffic behavior, these systems could predict and adapt to real-time conditions, enhancing safety outcomes.

Patel and Mehta (2021) further expanded the benefits of ABS beyond safety, showing that smoother braking reduces traffic congestion and emissions, contributing to environmental sustainability. However, Kumar and Singh (2022) noted challenges in widespread adoption, particularly cost and regulatory barriers in emerging markets. Moreover, O'Donnell and Dixit (2023) raised concerns over cybersecurity vulnerabilities in connected braking systems, highlighting the need for robust digital safeguards.

Methodology

This project implements a prototype of an automatic braking system using readily available components to simulate real-world ABS functionality. The system is designed to detect obstacles using an ultrasonic sensor and to activate a braking mechanism when a potential collision is detected.

Key Components:

- **Arduino Uno:** Acts as the microcontroller, processing data and issuing commands.
- **Ultrasonic Sensor:** Measures the distance between the vehicle and potential obstacles.
- **Relay Module:** Controls the motor connection based on sensor input.
- **Motors and Wheels:** Simulate the motion of a vehicle.
- **Buzzer:** Provides an audible alert when braking is initiated.
- **Power Supply:** Powers the electronic components.

Working Principle:

1. The ultrasonic sensor constantly measures the distance ahead of the vehicle.
2. If the measured distance falls below a predefined threshold (e.g., 40 cm), the Arduino processes this as an imminent collision.
3. The Arduino sends a signal to the relay to cut off power to the motor, stopping the vehicle.
4. Simultaneously, a buzzer is activated to alert the user.

Calculations:

To evaluate the performance of the automatic braking system, it is essential to calculate the total stopping distance of the vehicle model. This includes both the **reaction distance** (distance covered before the braking system activates) and the **braking distance** (distance required to bring the vehicle to a complete stop after braking begins).

Given Parameters:

- Obstacle detection distance = 40 meters
- Speed of the vehicle: $v = 10m/s$
- Deceleration due to braking, $a = 5m/s^2$
- Reaction time (system response delay), $t_r = 0.5\, seconds$
- Mass of vehicle model, $m = 4\, kg$

Step 1: Reaction Distance

This is the distance the vehicle travels during the system's response delay:

$$dr = v \times tr = 10 \times 0.5 = 5meters$$

Step 2: Braking Distance

Using the equation of motion:

$$d_b = \frac{v^2}{2a} = \frac{10^2}{2\,x\,5} = \frac{100}{10} = 10\, meters$$

Step 3: Total Stopping Distance

This means the vehicle comes to a complete stop within 15 meters after obstacle detection, ensuring a safe 25-meter buffer from the obstacle (40 m – 15 m).

$$d_{total} = d_r + d_b = 5 + 10 = 15meters$$

Step 4: Motor Power Requirement

To estimate the power required by the motor during normal operation:

- Force required to decelerate:

$$F = m \times a = 4 \times 5 = 20N$$

- Power:

$$P = F \times v = 20 \times 10 = 200 watts$$

Diagrams:

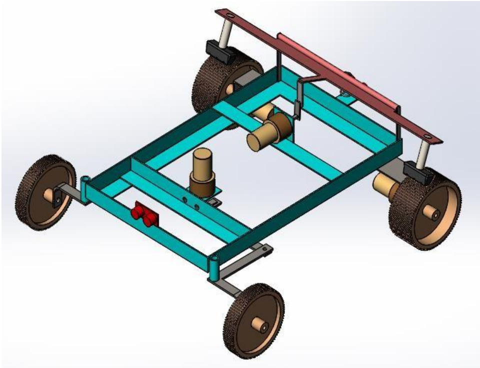

Figure 1: 3D Diagram of Model

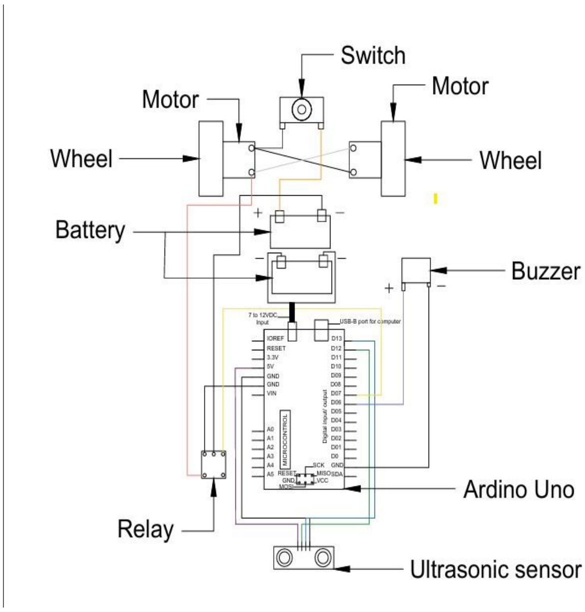

Figure 2: Circuit Diagram Of Model

Conclusion

The implementation of an automatic braking system significantly enhances vehicle safety by reducing the stopping distance and eliminating reliance on human reflexes during emergencies. The prototype successfully demonstrated the core functionality of ABS using ultrasonic sensors and microcontroller logic, stopping the vehicle within 15 meters of obstacle detection—well before reaching the object placed at a 40-meter distance.

Beyond improving reaction time, the system contributes to a smoother and safer driving experience. As this technology becomes more affordable and reliable, it holds strong potential for integration into commercial vehicles, especially as the automotive industry advances toward full vehicle autonomy. Future work may focus on integrating machine learning for adaptive response and exploring cybersecurity measures for system resilience in connected environments.

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