# Autonomous Navigation: An Arduino-Based Smart Car Obstacle Avoidance System

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## Abstract

Autonomous car navigation is currently attracting considerable research interest. The design of an Arduino-based smart car obstacle avoidance system includes the use of an ultrasonic sensor to detect obstacles and control the car's movement. The system is designed and developed to operate in a self-driven remote to avoid obstacles and reduce collisions. This paper presents the prototype development of a smart car obstacle avoidance system using an Arduino microcontroller and ultrasonic sensor. The research methodology operates by using an ultrasonic sensor to detect obstacles, emit sound waves, and measure the time it takes for the waves to be reflected. Arduino microcontroller serves as the system's control unit which enables the real-time analysis of sensor data and controls the movement of the car. Arduino microcontroller processes the data and calculates the distance of the obstacles. The direction and speed of the car is adjusted based on the calculated distance to avoid collision. The proposed system is intended to provide a cost-effective, efficient, and reliable obstacle avoidance system that could be used in various applications, such as robotics and automated vehicles. The success of the system is determined by the accuracy of the sensor data and the effectiveness of the control algorithms used to drive the car through the environment. Overall, the design of an Arduino-based smart car obstacle avoidance system is an interesting and innovative application of robotics technology.

**Keywords:** Arduino Microcontroller, Obstacle Avoidance, Robot, Servo Motor, Ultrasonic Sensor

## 1.0 Introduction

Rapid advancements in technology in the automation of robotic systems have allowed the progress of wheeled robots to reach a state of maturity. At present, autonomous mobile wheeled robots are extensively employed to transfer materials, nuclear weapons, military operations, and various other occupations [1]. These robots have contributed significantly by simplifying tasks that were earlier considered strenuous and time-consuming. Previous research has established the development of a smart car obstacle avoidance system based on the application of Arduino microcontroller [2]. The system uses ultrasonic sensors to detect obstacles and prevent collisions. The sensors send signals to the microcontroller, which controls the motors to change the direction of the car and avoid obstacles [1], [2]. Gunawan *et al.* [3] presented the system is designed to be modular and can be programmed using Arduino boards. The use of motor driver circuits and servo motors allows for precise control of the car's movements. The system has been evaluated and shows a high accuracy in obstacle detection. The Arduino-based smart car obstacle avoidance system has potential applications in various fields, including robotics and engineering [4].

Another study conducted by Divya et al. [5] suggests that an Arduino-based smart car obstacle avoidance system is feasible, cost-effective and efficient. In addition, Shabani et al. [6] developed a smart car control system for obstacle avoidance and engine temperature control using Arduino Uno, which avoided road obstacles and reduced engine breakdown due to excess engine temperature. Li et al. [7] designed and implemented an autonomous obstacle-avoiding robot car using ultrasonic wave sensors and an Arduino microcontroller, which effectively avoided obstacles. Goswami and Sahoo [8] designed a robotic vehicle to avoid obstacles using an Arduino microcontroller and ultrasonic sensor. This study demonstrates a practical application of Arduino microcontrollers and ultrasonic sensors in creating intelligent robotic systems. Meanwhile, Yılmaz and Özyer [9] developed a remote and autonomously controlled robotic car with real-time obstacle detection and avoidance using Arduino Uno, Bluetooth technology, and various sensors, which can detect live objects and flee from obstacles. Overall, these papers demonstrate the potential of Arduino-based smart car obstacle avoidance systems in reducing car accidents and improving safety.

The issue of creating efficient trajectory planning has resulted in the demand for robots that possess the ability to detect and steer clear of objects in a pre-calculated path or objects that suddenly emerge [9]. The resolution for this predicament comprises the utilization of sensors by the robot to recognize hurdles and sidestep them, thereby rendering the automaton more self-governing as it would not necessitate external support Riesen [10]. The primary objective of designing such a robot or technology is to enable its use in the fast-paced transportation industry today, reducing the occurrences of accidents that frequently happen in congested areas by applying an emergency brake [10]. If this technology were integrated into cars or any other vehicle, it would automatically sense obstacles and take a route to the available free space, potentially lowering vehicle accidents in the future [11].

Thus, the advancement of such technology may result in an enhancement in the overall safety of the transportation sector. The present study concerns the creation and execution of a smart robot car that avoids obstacles with the aid of artificial intelligence. This study aims to design a self-driving car that can recognize and evade obstructions on its path using artificial intelligence without any external aid. This project demands a combination of technological expertise and an in-depth understanding of the principles of robotics.

## 2.0 Methodology

This section presents the details of the hardware components and software implementations employed to formulate and execute the study.

### 2.1 Hardware Requirements

The phases that involve the physical implementation of the robot are known as the hardware implementation phases. This set of phases can be broken down into six distinct components, which include the HC-SR04 Ultrasonic Sensor, the SG-90 Servo Motor, the Arduino UNO R3, the L298D Motor Driver IC, the Power Supply, and the Left and Right DC Motors. All these components have been thoroughly explained in the chart given, along with their respective electrical diagrams used in the robot's design. Figure 1 shows the block diagram of the project hardware design. The project hardware consists of several main components such as ultrasonic sensors that provide the details of the entire process, facilitating a more thorough comprehension of the hardware design and development process. The hardware implementation phases play a crucial role in the development of the robot. It is essential to ensure that each component is correctly integrated to achieve maximum efficiency.

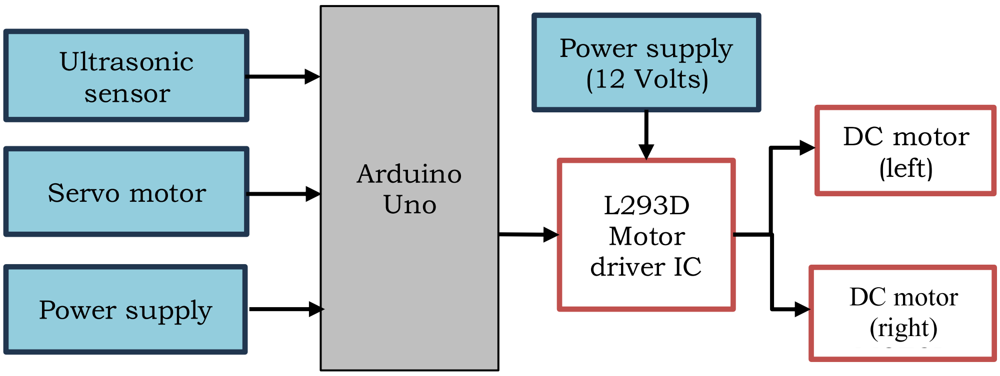
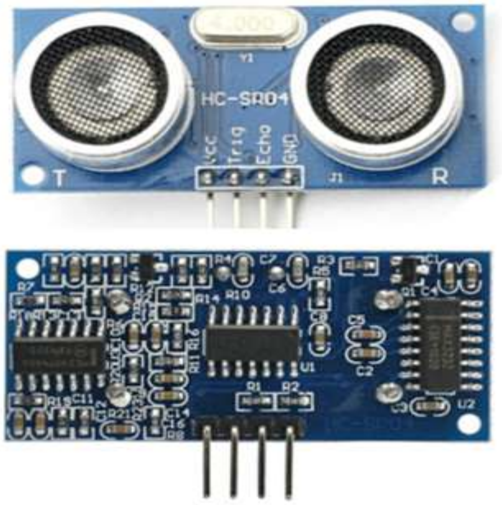
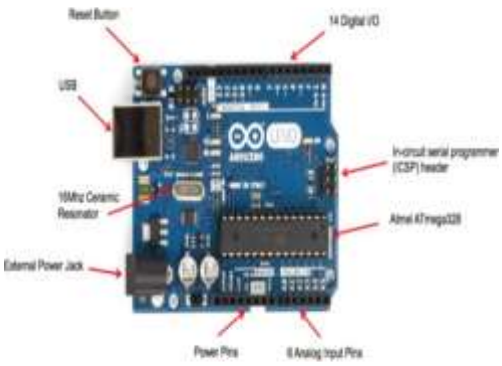



Figure 1: Block diagram of the project hardware design

Table 1: Description of the main component

| Component | Description | Figure |
|---|---|---|
| HC-SR04 Ultrasonic Sensor; SG-90 Servo Motor | The HC-SR04 ultrasonic sensor is powered by a 5V DC supply with a quiescent current of less than 2mA, a working current of 15mA, and an effective angle of less than 15 degrees. It is capable of ranging distances from 2cm to 400cm/1" - 13ft with a resolution of 0.3 cm and a measuring angle of 30 degrees, while the trigger input pulse width is 10uS. The sensor measures at 45mm x 20mm x 15mm**.** |   Figure 2**:** HC-SR04 ultrasonic sensor and SG-90 servo motor |
| L298D Motor Driver Shield | The L293D is a highly sophisticated integrated driver that can deftly manage enormous amounts of voltage and current. With four channels available, this chip is perfect for driving DC motors with a power supply of up to 36 Volts. In addition, every channel can provide a maximum of 600mA, making it an effective and dependable choice for regulating motors. This specific chip is additionally categorized as an H-Bridge, which is an electrical circuit that enables a voltage to be applied across a load in either direction to an output (such as a motor). Various applications benefit from the precise motor control offered by the versatile and functional L293D. Overall, this chip is an excellent |  Figure 3: L298D motor driver shield |

| Component | Description | Figure |
|---|---|---|
| | option for anyone looking for a reliable and efficient motor driver solution. It is different from the shield in [10]. | |
| Arduino UNO R3 | Arduino Uno Overview – Power<br>The Arduino Uno provides two options for powering, either via USB or through an external supply using the barrel jack connector. The external supply voltage range is limited to 7 to 12 DC. | <br>Figure 4: Arduino UNO R3 |

Upon activation of the Key Switch, the circuit will commence operation only if the switch is in an open position. The ultrasonic technology embedded within the circuit serves to identify any obstacles or objects in the vicinity, such as a car or wall. Once an obstacle is detected by the sensor, the vehicle will immediately come to a halt and manoeuvre backwards slightly. It should be taken into account that the ultrasonic sensor is solely capable of recognizing barriers that are under 15 centimetres away. Therefore, it is crucial to exercise due caution, especially when operating in an area with limited space or visibility. In conclusion, the incorporation of ultrasonic technology into the circuit has been demonstrated to be a crucial security feature for the automobile and its occupants. The schematic circuit for building the project is shown below.

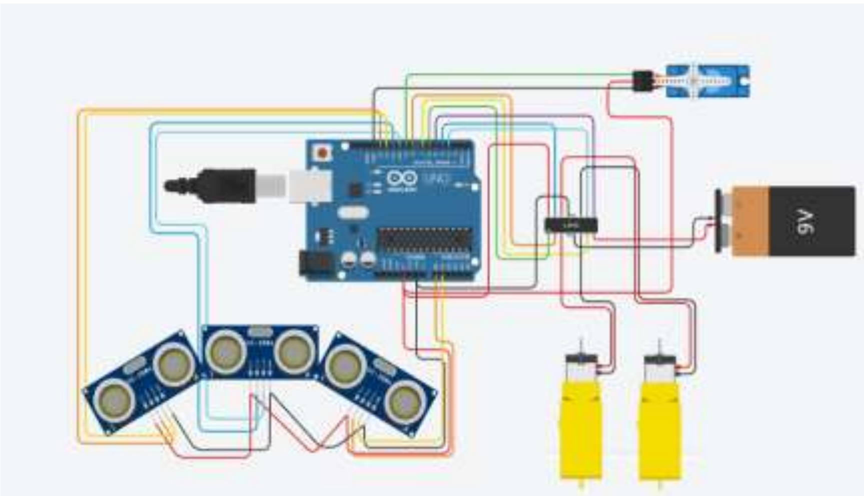


Figure 5: Schematic circuit

## 2.2 Software Requirements

This particular undertaking encompasses the programming that is indispensable to govern all Arduino-driven activities and movements. To render this programming viable for the Arduino, it must be erected and put forth through the utilization of the Arduino IDE application. This software application can operate with any microcontroller that is discernible within the software repository. As such, it provides an expansive range of compatibility options to facilitate the implementation of the requisite coding. Figure 6 shows the flowchart of the project system produced.

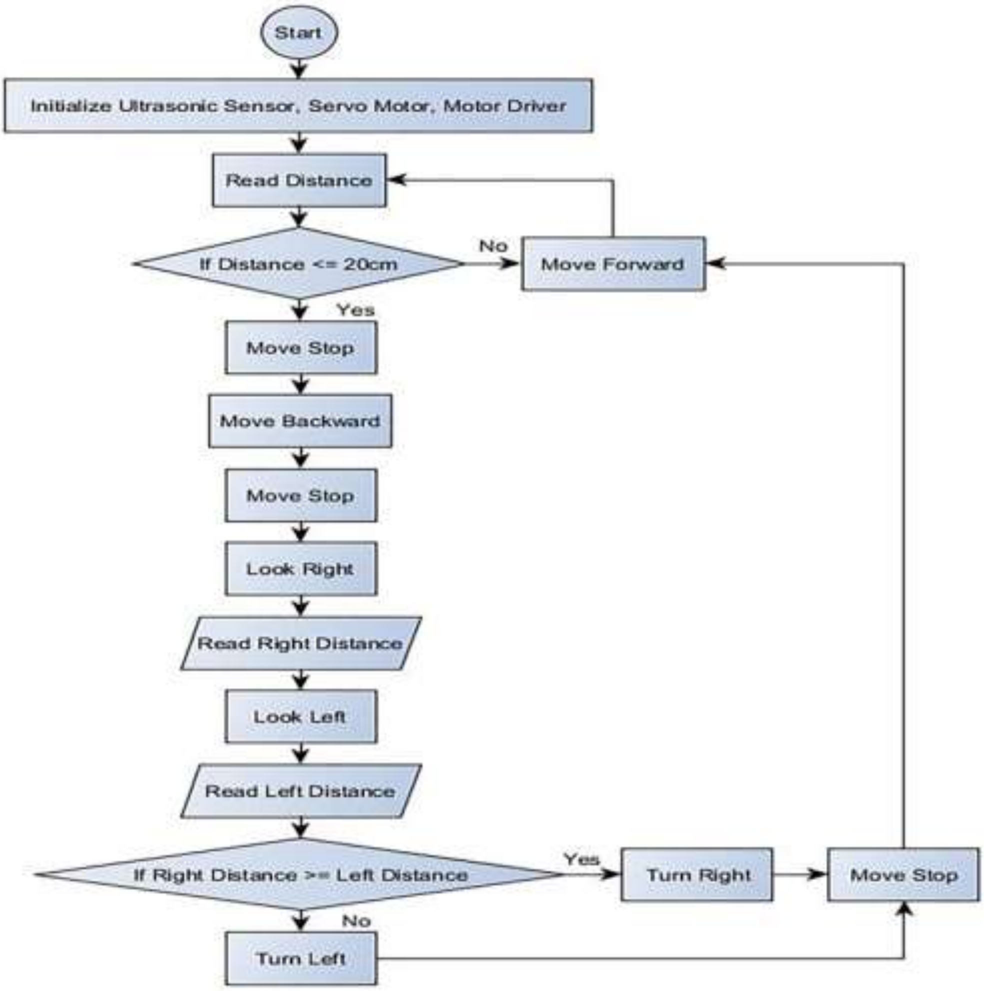



Figure 6: Flowchart of the project system produced

Upon activation, the four motors of the robot initiate their normal operation, propelling the robot forward. The ultrasonic sensor concurrently calculates the distance between the robot and any reflective surface that may be in its path. The Arduino then processes this information. If the robot senses an obstacle within 20cm, it stops and scans the immediate left and right using the Servo Motor and Ultrasonic Sensor. In case the left distance is larger than the right, the robot will ready itself for a left turn. However, before doing so, the robot will first reverse slightly and then engage the Left Wheel Motor. If the right distance is less than the left, the robot will prepare to turn right.

This cyclical process ensues indefinitely, enabling the robot to move unimpeded and without colliding with any obstacles.

## 3.0 Results and Discussion

The outcome of the current research is a robot vehicle that is controlled by an Arduino and can identify obstructions that could be present in its route and then avoid them. The robot deploys ultrasonic sensors during its operation to effectively transmit output ultrasound waves to three distinct positions: the front position at 90 degrees, the right position at 36 degrees, and the left position at 144 degrees. When the emitted wave strikes an obstacle, it bounces back, and the distance is recorded for the forward, right, and left positions.

The microcontroller evaluates the algorithm results and decides whether it should proceed or alter its trajectory. The analysis indicates that the proposed Arduino-controlled robot car is a promising novelty that can be employed in a wide range of uses. However, the system is notoriously ineffective, inefficient, and unreliable, and should be avoided for any future development or improvement. The study's outcomes propose that the proposed technology has noteworthy consequences for the fields of robotics and automation, and it can potentially optimize the efficiency and effectiveness of these systems in the coming years. The assessment conducted on the autonomous system manifests its proficiency in circumventing obstacles, as well as its adeptness in avoiding collisions and altering its position.

Tests conducted on the final hardware demonstrated the constraints of the detection algorithm. The limitations were associated with instances of certain obstacles failing to be detected. This was due to the sensor's inability to measure obstacles outside the sensor's measuring range. In instances where an object impedes the car's movement and is not within the sensor's line of sight, it will not be detected, resulting in a collision. To address this challenge, further testing was conducted in an enclosed area where the wall was the only obstacle, enabling the car to move freely without collision. However, to invent a vehicle that can identify multiple barriers and evade them, it would be necessary to use more sensors to cover a broader range of obstacle detection. The safety and reliability of the car is crucial considerations.

Figure 7: The mechanical design prototype

The system's accuracy, speed, and reliability are crucial factors to consider in the testing process. By comparing the results with existing designs or benchmarks, it is possible to assess the system's capabilities and identify areas for improvement. The system's performance can be evaluated through various metrics, such as the number of avoided obstacles and the response time to detected obstacles.

## 4.0 Conclusion

The design of an Arduino-based smart car obstacle avoidance system offers a practical and customizable solution for autonomous vehicles. By utilizing Arduino's flexibility and open-source nature, particularly for IoT applications [12], the system can be easily prototyped and adapted to different scenarios. The system's algorithm, sensor integration, and decision-making process enable real-time obstacle detection and avoidance, ensuring the safety and efficiency of the autonomous vehicle. A range of studies have explored the development of obstacle avoidance systems for autonomous vehicles, with a focus on enhancing safety and navigation. Mahmud et al. [10] and Goswami and Sahoo [8] both proved that ultrasonic sensors and the Arduino microcontroller detect and avoid obstacles, achieving high accuracy rates. Anand [13] expanded on this by incorporating AI and IoT devices, enabling the vehicle to detect traffic signals and signs. These studies collectively demonstrate the potential of Arduino-based smart car obstacle avoidance systems in improving safety and navigation. This analysis implies that the current design can accommodate additional functionalities with minimal or no human intervention. Hence, it is plausible to augment the system's capabilities to execute diverse tasks, thereby reducing the human workload. There is a need for further research on Arduino-based smart car obstacle avoidance systems, especially in the areas of hardware and software design, sensor technology, and real-time obstacle detection and avoidance. Further research and improvements can enhance the system's performance and expand its applications in various industries.

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**Author Contributions**

**Sharifah Nurulhuda Tuan Mohd Yasin**: Abstract, Methodology, Results and Discussion, Editing; **Maisatul Akmal Mat Tahir**: Introduction and Conclusion; **Iliyasu Hussaini**: Editing, Proofreading.

**Conflicts of Interest**

The manuscript has not been published elsewhere and is not under consideration by other journals. All authors have approved the review, agree with its submission, and declare no conflict of interest in the manuscript.

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