Design and Implementation of Ultrasonic Radar Using Arduino

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Abstract: This project presents the design and implementation of an Ultrasonic Radar System using the Arduino Uno, buzzer and the HC-SR04 Ultrasonic Sensor. The system is developed to detect objects and determining parameters such as distance, position, direction, speed and range which can be either in fixed or to be in motion. The ultrasonic sensor emits high-frequency sound waves and receives the reflected echo from objects. The Arduino Uno calculates the distance using the echo time-of-flight principle. A servo motor rotates the sensor from 0° to 180° to scan the area, and the measured distance and angle data are displayed on a computer as a radar-like visualization. If the object is detected then the buzzer sound will be activated. This system provides a simple, cost-effective, and efficient method for real-time object detection and distance measurement. It can be applied in obstacle detection, robotic navigation, security systems, and automation projects. The project demonstrates the practical use of embedded systems, sensor integration, and real-time data visualization.

Keywords: Arduino Uno, Ultrasonic Sensor (HC-SR04), Servo Motor (SG90), Jumper Wires, Breadboard, Buzzer , Computer with Processing Software**.**

I. Introduction

The Ultrasonic Radar System is a compact and cost-effective sensing solution designed to detect, locate, and visualize objects within a defined area using ultrasonic sound waves. When implemented using Arduino, this system becomes highly suitable for academic projects, research prototypes, and real-time embedded applications due to Arduino's simplicity, flexibility, and strong community support. An ultrasonic radar system operates on the echo-based distance measurement principle. The ultrasonic sensor emits high-frequency sound pulses (typically around 40 kHz), which travel through the air, strike an object, and reflect back to the receiver. By calculating the time taken for the echo to return, the system determines the distance of the object. When this sensor is mounted on a rotating mechanism such as a servo motor, it can scan across a wide angular range, mimicking the behavior of a conventional radar system. visualization on a computer or display interface. Such systems are widely used in obstacle detection, robot navigation, security surveillance, automotive parking assistance, and smart IoT applications. Overall, the design and implementation of an ultrasonic radar system using Arduino provide an excellent platform to understand embedded system design, sensor interfacing, signal processing basics, and real-time data visualization, making it a valuable and practical engineering project.

II. Literature Review

J. Smith et al. (2020), in the project titled *"Ultrasonic Radar System Using Arduino,"* used ultrasonic sensing, servo-based scanning, and Arduino processing techniques. The study found accurate short-range object detection with real-time visualization. However, the system has limitations such as restricted range and reduced accuracy when detecting soft or irregular surfaces.

Patil et al. (2021), in the project titled *"Ultrasonic Radar System Using Arduino Uno,"* utilized ultrasonic sensing, servo motor scanning, and microcontroller-based data processing techniques. The study demonstrated efficient real-time object detection and distance measurement. However, the system is limited by its short detection range and reduced performance in environments with noise or uneven object surfaces.

Karomah & Sartika (2022), in the project titled *"Design of Ultrasonic Radar System Using Arduino,"* employed ultrasonic sensing, servo motor rotation, and microcontroller-based signal processing techniques. The study achieved reliable object detection with real-time monitoring. However, the system is limited by short operational range and decreased accuracy when detecting soft, angled, or irregular surfaces.

A. Reddy & K. Raju (2023), in the project titled *"Arduino-Based Ultrasonic Radar System for Object Detection,"* utilized ultrasonic sensing, servo motor scanning, and microcontroller-based processing techniques. The study demonstrated efficient real-time object detection and accurate distance measurement with simple implementation. However, the system is limited by short sensing range, sensitivity to environmental noise, and reduced accuracy when detecting soft, angled, or irregular surfaces.

S.Ahmed & R. Chaudhary (2021), in the project titled *"Ultrasonic Radar System for Object Detection Using Arduino,"* utilized ultrasonic sensing, servo motor rotation, and Arduino-based processing techniques. The study achieved reliable real-time object detection and distance measurement with good accuracy. However, the system is limited by short detection range, sensitivity to environmental noise, and reduced performance on soft, angled, or irregular surfaces.

N. Sharma & V. Singh (2022), in the project titled *"Design and Implementation of Ultrasonic Radar System Using Arduino,"* utilized ultrasonic sensing, servo motor scanning, and microcontroller-based processing techniques. The study demonstrated efficient real-time object detection with good accuracy. However, the system is limited by short operational range, sensitivity to environmental noise, and reduced performance when detecting soft or irregular surfaces.setup. This initial configuration ensures that the system begins operation from a stable and known reference point.Once initialized, the Arduino sends a 10-microsecond trigger pulse to the ultrasonic sensor, causing it to emit high-frequency sound waves. These waves travel through the air and reflect back upon hitting an object. The sensor receives the echo signal, and the Arduino measures the time taken between transmission and reception. Using this time and the speed of sound (343 m/s), the system calculates the distance. This process helps determine object position accurately at each scanning angle.After calculating distance, the system compares it with a predefined threshold value. If the measured distance is less than the threshold, the buzzer turns ON; otherwise, it remains OFF, ensuring alerts only when needed.

Distance is calculated using the formula: $\text{distance} = \dfrac{\text{Time} \times \text{Speed of sound}}{2}$

D. Lee & J. Kim (2021), in the project titled *"Arduino-Based*

Ultrasonic Radar System for Object Detection," utilized ultrasonic sensing, servo motor scanning, and microcontroller-based processing techniques. The study achieved accurate real-time distance measurement and object detection. However, the system is limited by short sensing range, sensitivity to environmental noise, and reduced accuracy when detecting soft, angled, or irregular surfaces.

K. Singh & P. Gupta (2022), in the project titled *"Development of Ultrasonic Radar System Using Arduino for Object Detection,"* utilized ultrasonic sensing, servo motor scanning, and Arduino-based signal processing techniques to detect objects and measure distances. The study achieved reliable real-time monitoring with good accuracy and simple implementation. However, the system is limited by short detection range, sensitivity to environmental noise, and reduced performance when detecting soft, angled, or irregular surfaces.

III METHODOLOGY

The proposed ultrasonic radar system using Arduino Uno is designed to perform real-time object detection and distance measurement by integrating sensing, processing, and actuation components. The methodology of the system begins with the initialization stage, where all hardware components such as the Arduino Uno, ultrasonic sensor (HC-SR04), servo motor, and buzzer are configured properly. At the start, the servo motor is positioned at 0°, which acts as the initial scanning angle, and the buzzer is set to the OFF state to avoid false alerts during system

- Speed of sound = **0.034 cm/µs**
- Division by 2 → because wave travels **to object and back**

Threshold Condition:

- If Distance < Threshold → Buzzer ON
- If Distance ≥ Threshold → Buzzer OFF

Following the detection and alert process, the servo motor is rotated to change the scanning direction of the ultrasonic sensor. The servo motor moves in small incremental steps, allowing the sensor to scan different angles. This rotation

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enables the system to cover a wide field of view, typically ranging from 0° to 180°. At each step, the same process of triggering the ultrasonic sensor, receiving the echo, and calculating the distance is repeated. This continuous scanning helps in building a comprehensive understanding of the surrounding environment.The system then checks whether the servo motor has reached the maximum scanning angle of 180°. If the angle is less than 180°, the servo continues to rotate forward, and the scanning process repeats at each step. Once the servo reaches 180°, the system changes the direction of rotation, and the servo begins to move back toward 0°. This reverse motion ensures that the scanning is continuous and does not stop at the end of one cycle. The back-and-forth movement allows the system to repeatedly monitor the entire scanning area without interruption. This entire process operates in a loop, ensuring continuous detection and monitoring of objects in real time.

distance measurement, Arduino Uno for processing, servo motor for directional control, and buzzer for alert generation makes the system efficient and reliable. The methodology ensures that the system can detect obstacles accurately, provide timely alerts, and scan a wide area effectively. Such a system can be applied in various fields, including robotic navigation, security surveillance, and assistive devices for obstacle detection, demonstrating its practical significance and versatility .

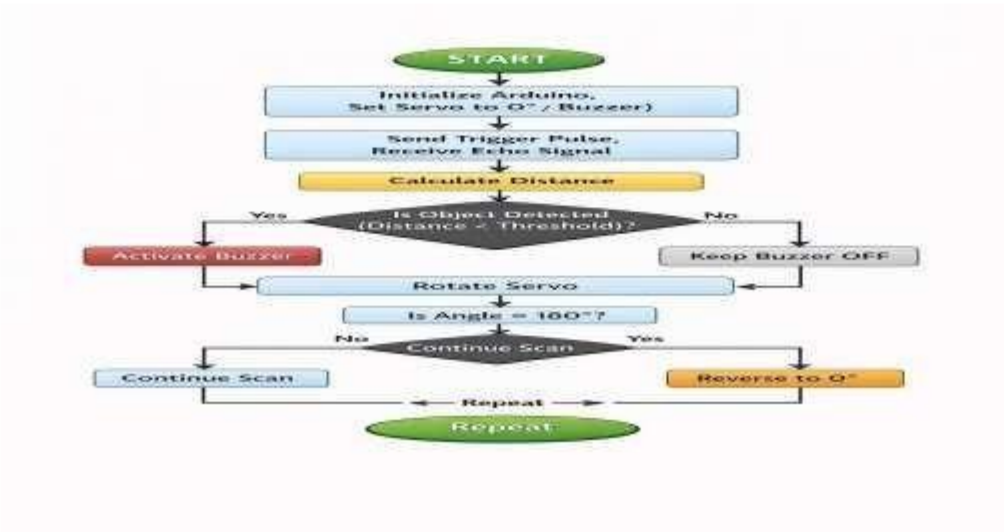

Figure 1: Flow of the Project

IV DESIGN IMPLEMENTATION OF RADAR SYSTEM

Design and implementation of a radar system using Arduino, ultrasonic sensor, servo motor, and buzzer to detect objects, measure distance, scan surroundings, and provide real-time alerts through sound signals.

a) System circuit design

b) System circuit implementation on breadboard

System circuit design

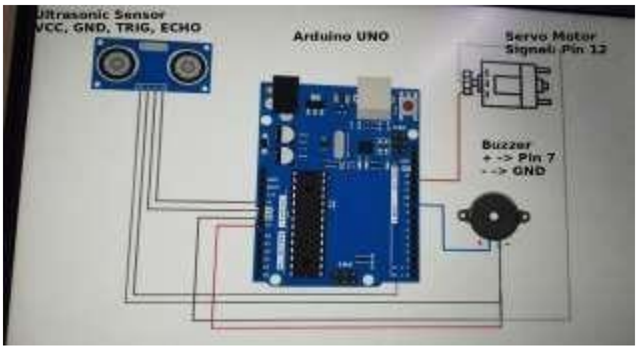

Figure 2: Circuit Diagram of RADAR System

Figure 1 shows the circuit design of a radar system using an Arduino UNO, ultrasonic sensor, servo motor, and buzzer. The ultrasonic sensor is connected to 5V, GND, and digital pins 10 (TRIG) and 11 (ECHO) for distance measurement. The servo motor is connected to pin 12 to

rotate the sensor and scan the surroundings. The buzzer is connected to pin 7 and GND to provide alerts when objects are detected nearby. All components share a common ground. The Arduino controls sensing, scanning, and alert functions, enabling real-time object detection and simple radar operation.

System circuit implementation on breadboard

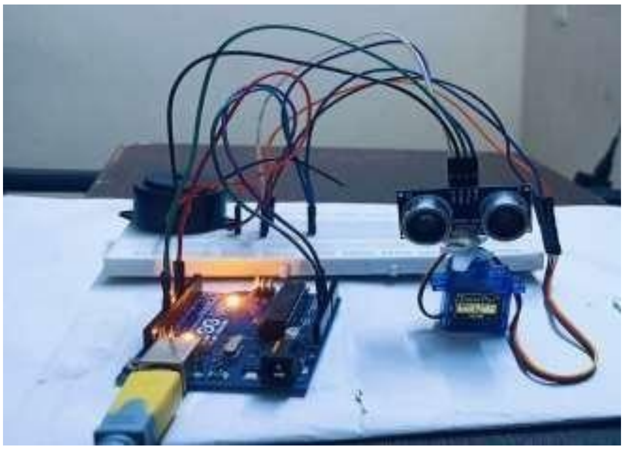

Figure 3: ultrasonic radar system built using an Arduino Uno

The setup shown in Figare2 is an ultrasonic radar system built using an Arduino Uno, an HC-SR04 ultrasonic sensor, a micro servo motor SG90, and a buzzer. The Arduino acts as the central controller, coordinating all components. The ultrasonic sensor

measures distance by sending high-frequency sound waves and receiving their echoes after reflecting from nearby objects. The servo motor rotates the sensor across different angles, typically from 0° to 180°, enabling scanning of the surroundings similar to a radar system. At each position, the Arduino calculates the distance based on the time taken for the echo to return. If an object is detected within a predefined threshold distance, the buzzer is activated as an alert. Otherwise, it remains off. This system continuously scans and detects obstacles in real time, demonstrating principles of embedded systems, sensor interfacing, and automation in a simple and effective way.

Hardware Description

- Ultrasonic Sensor

- Arduino Uno

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The Arduino Uno acts as the main controller of the system. It reads input data from the ultrasonic sensor, processes the distance values, and controls the servo motor and buzzer accordingly. It runs the programmed code to coordinate scanning, detection, and alert functions, ensuring smooth and real-time operation.

- ❖ Servo motors (MG995 / SG90) and buzzer

A servo motor is a compact actuator used for precise control of angular position, typically between 0° and 180°. It operates using a control signal from a microcontroller like Arduino. In this project, it rotates the ultrasonic sensor to scan the surroundings, enabling directional detection of objects efficiently.

The buzzer provides an audible alert when an object is detected within a certain threshold distance. It is activated by the Arduino based on sensor readings. The sound pattern can vary depending on how close the object is, helping users understand proximity through audio signals.

- ❖ Breadboard:

Breadboard is used for assembling and connecting all components without soldering, providing easy wiring, proper power distribution, and flexibility for testing and modifications.

The integration of these components creates an efficient ultrasonic radar system capable of real-time object detection, directional scanning, and alert generation, making it reliable for practical embedded and automation applications.

V RESULTS AND DISCUSSION

Simulation Output

The simulation, performed using Arduino and Processing, produced real-time radar visuals demonstrating successful object detection, coordinate mapping, and accurate distance measurement**.**

The code controls an ultrasonic radar system using Arduino. A servo motor rotates the sensor from 0° to 180°, measuring distance using echo time. The data is sent via serial communication to Processing for visualization. A buzzer provides alerts based on object proximity, indicating near, medium, and far distances.

Interpretation of Results:

Figure 1 illustrates the radar output when the ultrasonic sensor detects an object at an angle of approximately 78° and a distance of 151 cm. The sweeping green line indicates the current scanning direction of the servo motor. The red lines represent detected objects, which appear less dense due to the object being relatively far from the sensor. The concentric arcs denote distance ranges, helping visualize object positioning. Overall, the figure demonstrates the system's ability to detect distant objects with moderate signal intensity.

Figure 2 presents the radar output when the ultrasonic sensor detects an object at an angle of approximately 89° and a distance of 95 cm. The green sweeping line indicates the current direction of the servo-mounted sensor, which is nearly at the center of the scanning range. The red lines represent detected objects and appear denser and brighter compared to Figure 1, indicating a stronger echo signal due to the object being closer. The concentric arcs mark distance intervals, aiding in visual estimation of object position. This figure clearly demonstrates that the system provides more accurate and intense detection when objects are located nearer to the sensor.

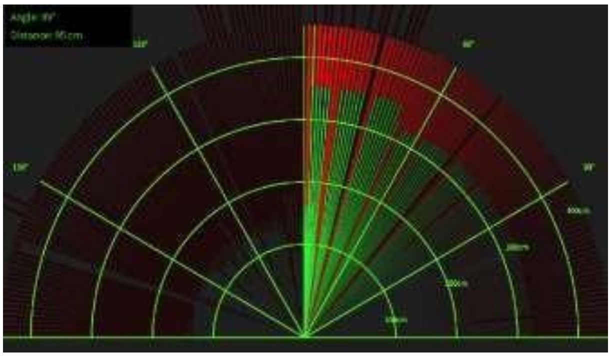
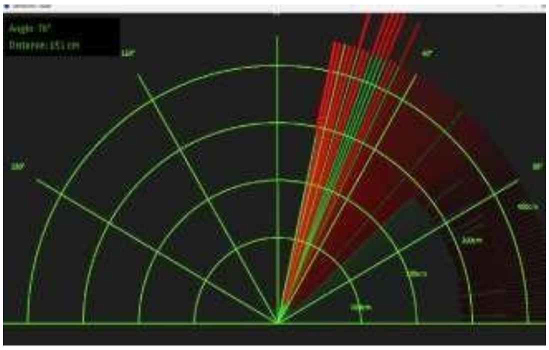
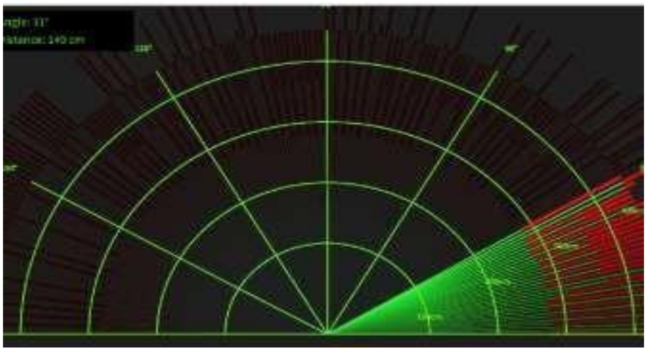


Figure 3 illustrates the radar output when the ultrasonic sensor detects an object at an angle of approximately 31° and a distance of 149 cm. The green sweeping sector shows the active scanning region of the servo motor. The red lines on the right side indicate detected objects, which are moderately dense due to the object being at a mid-range distance. The concentric arcs represent distance intervals up to 400 cm. This figure demonstrates the system's capability to detect objects at different angles with consistent accuracy and visualization.





VI FUTURE SCOPE

Industrial Safety Applications

- Collision avoidance systems
- Automated guided vehicles (AGVs)
- Robotic arms

Smart Vehicle Integration

- Parking assistance
- Blind-spot detection

Defense and Security Applications

- Border surveillance
- Motion tracking in restricted areas

VII CONCLUSION

The Ultrasonic Radar System using the Arduino Uno is a simple, cost-effective, and efficient solution for real-time object detection and distance measurement. By integrating an ultrasonic sensor, servo motor, and buzzer, the system successfully scans the environment and provides accurate positional data. The use of radar visualization enhances understanding of object location and movement. This project demonstrates the practical application of embedded systems, sensor integration, and real-time processing. Furthermore, it serves as a strong foundation for advanced developments in robotics, automation, and smart monitoring systems, making it highly valuable for both academic learning and real-world applications.

VIII ACKNOWLEDGEMENTS

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