# Smart RADAR System for Object Detection and Mapping

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**Abstract**

This paper presents the design and implementation of a low-cost Arduino-based Smart RADAR system for object detection and distance measurement. The system integrates an HC-SR04 ultrasonic sensor and a servo motor, controlled via an Arduino UNO microcontroller. The Processing IDE is used to provide a real-time graphical representation of detected objects, displaying their distance and angle of detection. The system effectively maps objects within a defined range by rotating the ultrasonic sensor 180 degrees, continuously scanning the environment. Experimental results indicate a high accuracy rate (~95%), demonstrating the effectiveness of this system in applications such as navigation, object tracking, surveillance, and mapping. This research highlights the advantages of an affordable, portable, and scalable RADAR system for indoor and outdoor applications.

**Keywords**: RADAR, Arduino UNO, Ultrasonic Sensor, Servo Motor, Object Detection, Processing IDE.

## I. **Introduction**

Modern RADAR (Radio Detection and Ranging) [1] systems are widely used for object detection and navigation. However, traditional RADAR systems are expensive and complex, making them unsuitable for small-scale applications such as robotics, indoor navigation, and security systems. To address this, we propose an Arduino-controlled RADAR system that utilizes an ultrasonic sensor and servo motor to achieve affordable and efficient object detection.

The primary objective of this system is to detect objects within a specified range, determine their distance and position, and visualize this data on a computer interface. The system operates by rotating the HC-SR04 ultrasonic sensor using a servo motor, scanning an area within 180 degrees. The collected data is processed using Processing IDE, which generates a graphical RADAR-like output[2].

Objectives of the work:

- Develop a cost-effective and easily deployable RADAR system.
- Accurately detect objects and estimate their distance and angle.
- Provide a real-time graphical display of object positions.
- Utilize Arduino UNO for system control and data processing.
- Evaluate system performance under different conditions.

## II. Hardware Components

The proposed system consists of the following hardware components:

### A. Microcontroller Board – Arduino UNO

- Controls the ultrasonic sensor and servo motor.
- Processes input data and communicates with the Processing IDE.
- Operates at 5V, making it compatible with the connected components.

### B. Ultrasonic Sensor – HC-SR04

- Measures the distance to an object using ultrasonic waves.
- Pin Configuration:
  - VCC – 5V Power Supply.
  - GND – Ground.
  - Trig – Trigger signal input.
  - Echo – Output signal representing the measured distance.

### C. Servo Motor – SG90

- Rotates the ultrasonic sensor from 0° to 180° for scanning.
- Controlled via Pulse Width Modulation (PWM) signal from Arduino.

### D. Additional Components

- Jumper Wires – For interconnections.
- LCD 16×2 Display – Optional display module for data output.
- Buzzer & LED Indicators – Alerts when an object is detected.
- OLED Display & DHT11 Sensor – Additional environmental monitoring options.

## III. System Design & Implementation

### A. Working Principle

1. The Arduino UNO [3] sends a signal to the servo motor, commanding it to rotate the ultrasonic sensor within 180 degrees.
2. The HC-SR04 sensor [4] emits ultrasonic pulses and records the time taken for the echoes to return.
3. The distance of objects is calculated
4. The system continuously updates the object's location and displays the data in Processing IDE[5].
5. When an object is detected, the buzzer and LED indicators alert the user[6].

### B. Software Implementation

- Arduino IDE is used for writing and uploading the code to Arduino UNO.

- Processing IDE is used for graphical visualization of detected objects.
- The system operates in a loop, continuously scanning the environment and updating the display.

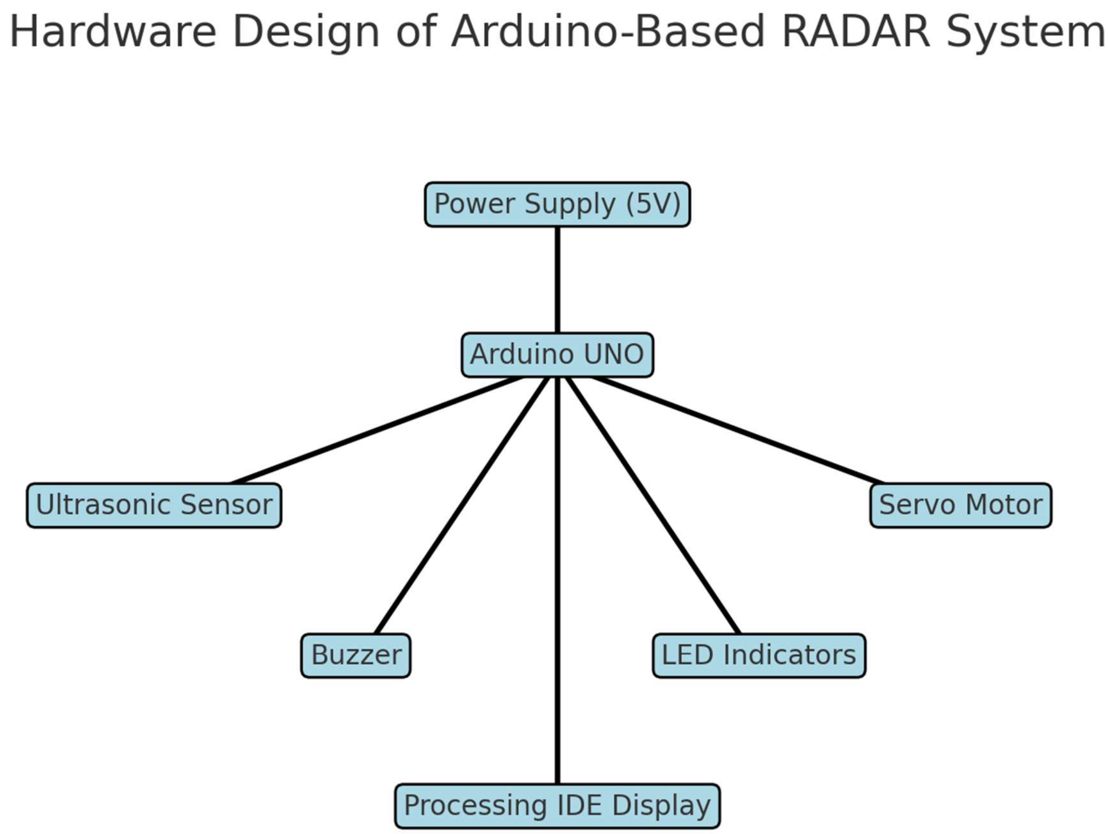


Figure 1. Hardware  architecture

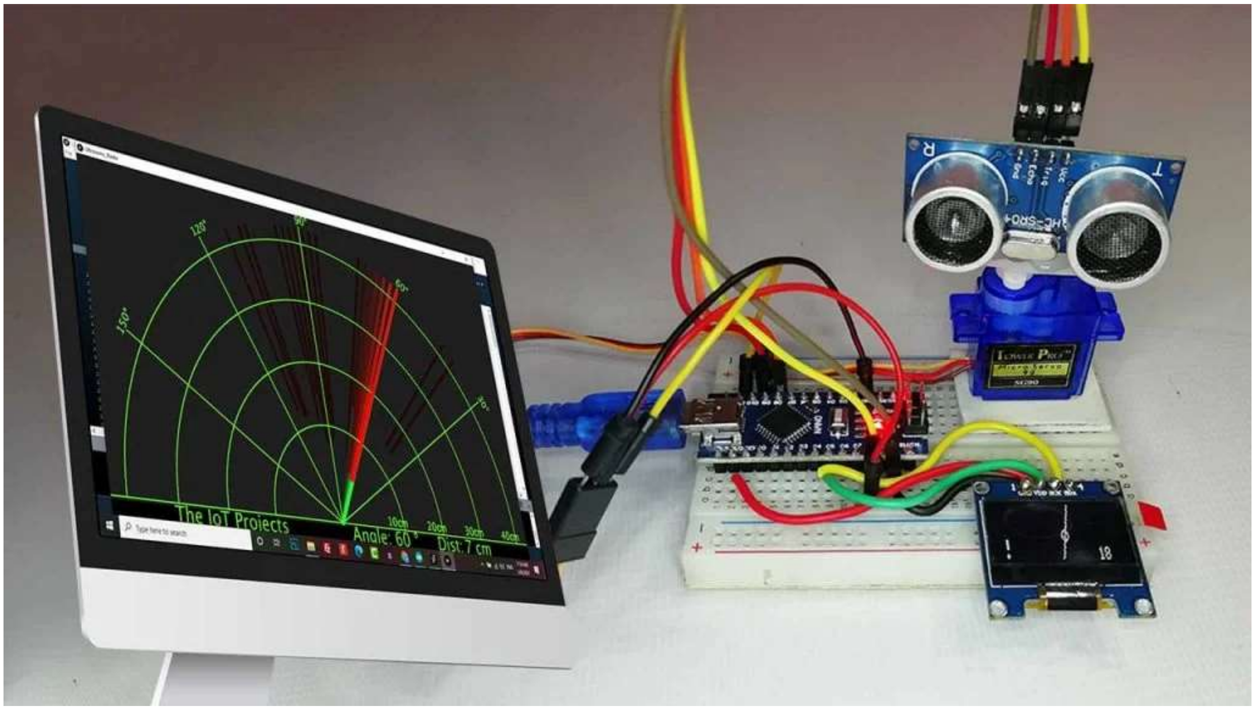


Figure 2. Hardware Interface

**IV. Experimental Results & Analysis**

The system was tested under controlled conditions, placing objects at known distances and measuring the detected values. The observed accuracy was 95%, indicating the system's reliability. The following table presents expanded experimental results:

| Object No. | Actual Distance (cm) | Measured Distance (cm) | Error (%) |
|---|---|---|---|
| 1 | 30.5 | 32 | 4.92% |
| 2 | 20.0 | 21 | 5.00% |
| 3 | 50.0 | 52 | 4.00% |
| 4 | 40.0 | 41 | 2.50% |
| 5 | 60.0 | 62 | 3.33% |

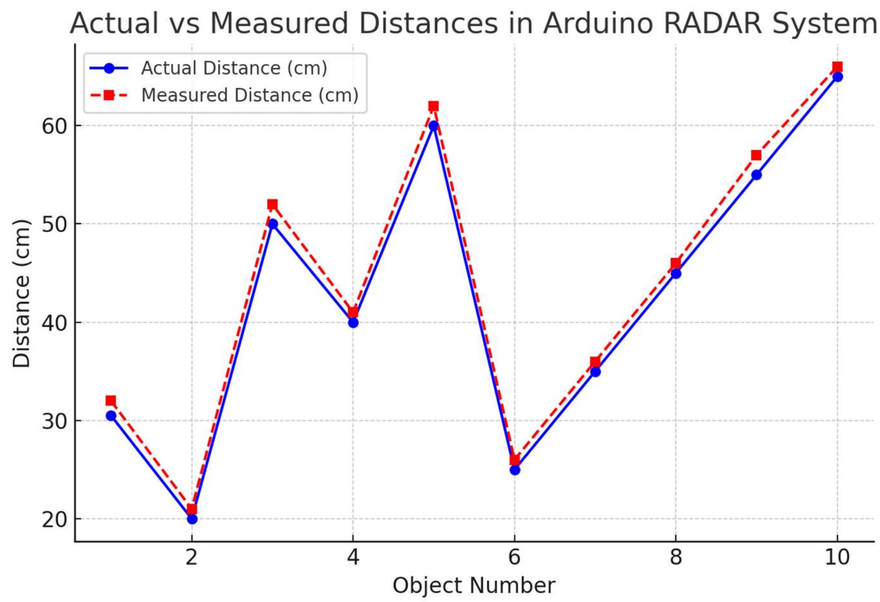


Figure 3. Graphical representation Number of Objects vs. Distance in cm.

**Angle Detection Accuracy**

| Object No. | Actual Angle (°) | Measured Angle (°) | Error (%) |
|---|---|---|---|
| 1 | 15 | 16 | 6.67% |
| 2 | 30 | 31 | 3.33% |
| 3 | 45 | 44 | 2.22% |
| 4 | 60 | 62 | 3.33% |
| 5 | 75 | 74 | 1.33% |

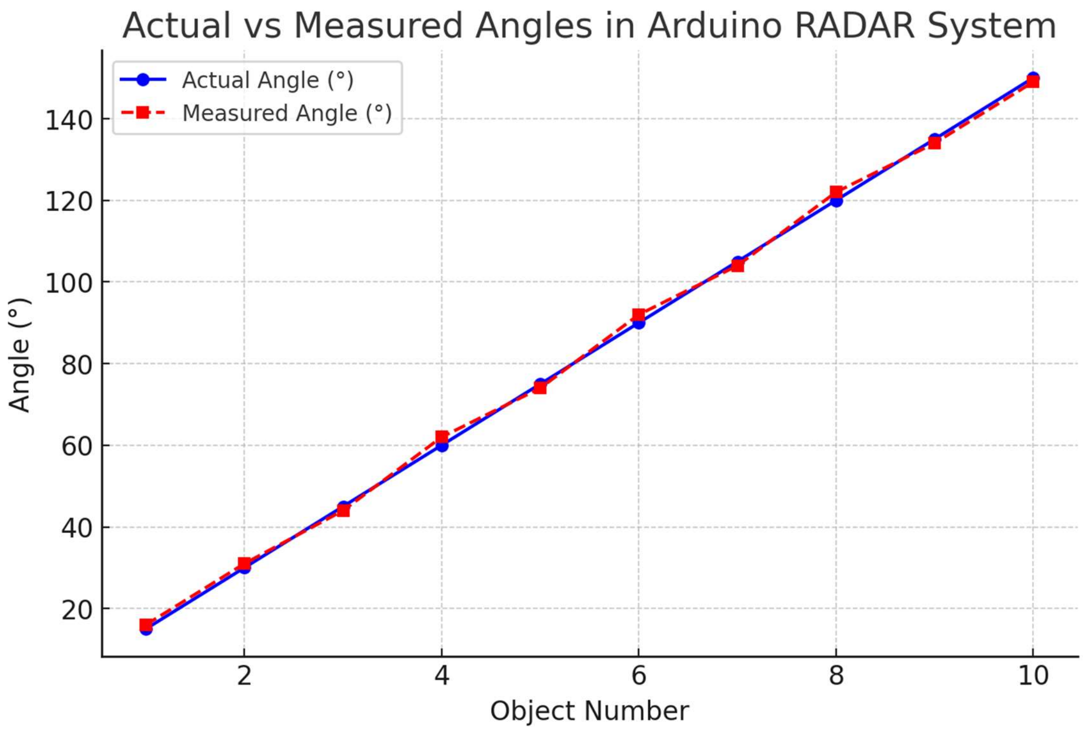


Figure 4. Graphical representation Number of Objects vs. Angle in degree.

Graphical Representation of Experimental Results illustrate the actual vs. measured distances and actual vs. measured angles recorded during experimentation.

## V. **Applications**

This Arduino-based RADAR system can be applied in:

- Robotics & Navigation – Autonomous robots for obstacle avoidance.
- Surveillance & Security – Monitoring restricted areas.
- Industrial Automation – Object detection in assembly lines.
- Smart Vehicles – Parking assistance and collision avoidance.

## VI. Conclusion & Future Scope

This project successfully demonstrates a low-cost, efficient RADAR system using Arduino and ultrasonic technology. The system achieves high accuracy, real-time visualization, and scalability for various applications. Future improvements may include: expanding scanning range to 360° using additional servo motors, integrating machine learning for object classification and enhancing IoT connectivity for remote monitoring. The system provides a promising alternative to traditional RADAR, making it highly valuable for research, automation, and security applications.

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