Arduino Radar for Object Detection

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Abstract: *This project, titled "Arduino Radar Object Detection System," involves the design and development of a cost-effective, real-time object detection and distance measurement system using Arduino microcontroller integrated with ultrasonic sensors and servo motors. The system continuously scans the surrounding environment, detects objects, measures their distance, and displays the data on a visual radar interface. The working principle is based on an embedded systems architecture utilizing Arduino UNO, HC-SR04 ultrasonic sensors, SG90 servo motors, and Processing software for radar visualization, which seamlessly creates an autonomous surveillance solution.*

The main objective of this project is to develop an accessible, automated, and reliable object detection system suitable for security applications, obstacle detection, and autonomous navigation in robotics. The Arduino Radar platform reduces dependency on expensive commercial radar systems, enables real-time object detection and distance calculation, and provides accurate spatial awareness compared to conventional offline detection methods. System design and research confirm that the platform performs reliably as an object detection mechanism, demonstrating the practical application of embedded systems and sensor technology in modern surveillance and navigation applications..

Keywords*: Arduino, Radar System, Object Detection, Ultrasonic Sensors, Real-Time Detection, Embedded Systems, Distance Measurement*

I. INTRODUCTION

ARDUINO RADAR OBJECT DETECTION SYSTEM is an embedded systems project developed to detect and locate objects in real-time using Arduino microcontroller and ultrasonic sensing technology. The main goal of the system is to create an automated surveillance mechanism that scans the environment, identifies obstacles, and calculates their precise distance and angular position. Many applications require accurate object detection and distance measurement—from security systems monitoring restricted areas to autonomous robots navigating unknown environments. Traditional commercial radar systems are expensive, require specialized infrastructure, and consume significant power. These conventional approaches often involve complex installation, extensive calibration, and high maintenance costs. As a result, many small-scale enterprises and educational institutions cannot implement effective surveillance or navigation solutions. To solve these challenges, the ARDUINO RADAR provides a cost-effective embedded solution where objects can be detected automatically through continuous environmental scanning. The system includes features such as real-time object detection, accurate distance measurement, angular position tracking, visual radar display, and data logging capabilities. By bringing these functionalities together in one integrated system, the Arduino Radar helps create effective surveillance and navigation solutions. The system is developed using embedded systems technologies such as Arduino UNO microcontroller, HC-SR04 ultrasonic sensors, SG90 servo motors, and Processing software for visualization, ensuring a secure, scalable, and user-friendly platform. With real-time data display and a simple graphical interface, the Arduino Radar is designed to be easily understood even by users with limited electronics knowledge.

In the era of smart automation and IoT, the Arduino Radar demonstrates how embedded systems can provide practical solutions by improving object detection capabilities, increasing spatial awareness, and supporting autonomous decision-making in various applications. The platform aims to empower developers and engineers with affordable tools and automated detection capabilities, ultimately improving surveillance effectiveness, navigation accuracy, and system reliability

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DOI: 10.48175/IJARSCT-32029

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ISSN
2581-9429
IJARSCT

II. LITERATURE SURVEY

Object detection and distance measurement are critical requirements in various applications including security systems, autonomous vehicles, robotics, and industrial automation. Many researchers and organizations have explored the use of sensor technology and microcontroller-based systems to achieve real-time object detection and distance calculation. Embedded systems combined with ultrasonic sensors provide a cost-effective alternative to expensive commercial radar systems. According to studies on embedded systems and sensor technology, integrating ultrasonic sensors with microcontrollers improves detection accuracy, reduces system complexity, and enables autonomous operation. Several projects such as Arduino-based collision detection systems, ultrasonic rangefinders, and automated obstacle avoidance platforms have demonstrated the effectiveness of this approach. These systems utilize HC-SR04 ultrasonic sensors that emit sound waves to detect objects and calculate distance based on the time-of-flight principle. However, many existing object detection systems are limited to single-direction sensing or static installations, making them difficult to scan large areas or provide comprehensive spatial awareness. Therefore, there is a need for a dynamic system that combines rotational scanning capability with accurate distance measurement to create a comprehensive radar solution.

The ARDUINO RADAR OBJECT DETECTION SYSTEM is designed to address these limitations by providing a unified platform where a rotating ultrasonic sensor can scan 180 degrees or more, detect objects in multiple directions, calculate precise distances, and display the data in an intuitive radar visualization format. The project uses modern embedded systems technologies such as Arduino UNO microcontroller for processing, HC-SR04 sensors for distance measurement, servo motors for mechanical rotation, and Processing software for graphical radar display

Previous research also emphasizes the importance of real-time data visualization in detection systems to ensure quick operator response and accurate situational awareness. The Arduino Radar system incorporates live radar visualization where detected objects appear as blips on a rotating radar screen, making the detection results immediately comprehensible to users.

Thus, the development of the ARDUINO RADAR contributes to the growing field of embedded systems and IoT by combining sensor technology, microcontroller programming, and real-time visualization into one integrated platform. The system demonstrates how Arduino and complementary technologies can create practical surveillance and navigation solutions, improve object detection capabilities, and promote cost-effective automation.

III. SCOPE OF THE PROJECT

The scope of the Arduino Radar Object Detection System is to design and develop an automated embedded systems solution that provides real-time object detection, distance measurement, and spatial visualization capabilities .

The platform aims to support security applications, robotics research, and educational demonstrations by offering reliable object detection technology utilizing ultrasonic sensing principles. The system will integrate multiple components—including microcontroller programming, sensor interfacing, mechanical actuation, and software visualization—to deliver comprehensive detection functionality.

Functional Scope:

1. The functional scope of the Arduino Radar Object Detection System defines the main operations and services that the embedded system provides to achieve accurate object detection

2. One of the main functions of the system is real-time object detection, where the ultrasonic sensor mounted on a rotating servo motor continuously scans the environment and identifies objects within the detection range (typically 2 cm to 400 cm)

3. Another important function is distance measurement and calculation, which uses the ultrasonic time-of-flight principle to measure the precise distance of detected objects from the sensor

4. The platform includes angular position tracking, where the system records the servo motor angle corresponding to each detected object, enabling precise spatial localization .

5.The system supports real-time radar visualization using Processing software, where detected objects are displayed as visual blips on a rotating radar screen, with distance represented radially and angle represented angularly

6. Additionally, the system includes data logging and storage capabilities, allowing historical tracking of detected objects, detection patterns, and system performance metrics.

7. The system also supports manual control and calibration, enabling users to adjust scanning parameters, sensitivity thresholds, and display settings

Non-Functional Scope:

1. The non-functional scope of the Arduino Radar system describes the quality attributes and system requirements that ensure reliable and accurate operation.

2. One of the key non-functional aspects is accuracy. The system must provide precise distance measurements with minimal error margins.

3. Another important requirement is real-time performance. The system must scan, detect, and display objects with minimal latency.

4. Reliability is also an important factor. The system must maintain continuous operation without crashes or sensor failures.

5. The platform must also ensure robustness, functioning reliably in various environmental conditions including different lighting and temperatures.

6. Finally, scalability and modularity are important non-functional requirements. The system should allow integration of additional sensors and expansion without major changes.

IV. METHODOLOGY / APPROACH

The development of the ARDUINO RADAR system follows a Linear Sequential Model, ensuring that each phase is completed before the next begins. This structured approach ensures accuracy, reliability, and scalability.

Step 1: Problem Analysis & Requirement Gathering

The foundation of the project is based on identifying the need for cost-effective object detection in real-time applications. To define the functional requirements of the system, such as scanning range, detection sensitivity, distance accuracy, and visualization requirements

Step 2: System Architecture & Design

This phase translates requirements into a technical blueprint. The system is designed using a Layered Architecture:
• Sensor Layer: HC-SR04 ultrasonic sensors for distance measurement, interfaced with Arduino through digital I/O pins.
• Control Layer: Arduino UNO microcontroller for sensor data acquisition, processing, servo motor control, and serial communication.
• Actuation Layer: SG90 servo motors for mechanical rotation of sensor mounting platform.
• Visualization Layer: Processing software for real-time radar display.

Step 3: Development & Modular Implementation

During this stage, the project is broken down into independent functional modules:
• Sensor Interfacing Module: Code to trigger HC-SR04 sensors and read distance data.
• Servo Motor Control Module: Logic to control servo motor rotation and positioning.
• Data Processing Module: Algorithms to calculate distances and filter sensor noise.
• Serial Communication Module: Code to transmit detection data to Processing.
• Visualization Module: Graphics rendering for radar display with detected objects.

Step 4: Testing & Quality Assurance

Before deployment, the system undergoes rigorous testing:

• Unit Testing: Each module tested individually for accuracy.

• Integration Testing: Ensuring correct communication between components.

• System Testing: Complete system verification in various environments.

• Performance Testing: Evaluating system latency and reliability under continuous operation.

Step 5: Implementation & Deployment

• Deployment: The system is hosted and made accessible for real-time operation.

• Maintenance: The system provides continuous surveillance where information is updated regularly, ensuring long term utility for detection and security applications

V. ADVANTAGES

1. Cost-Effective Solution: Arduino and HC-SR04 sensors are affordable components, making the system significantly cheaper than commercial radar systems..

2. Easy Implementation: The modular design allows developers to easily understand, modify, and expand the system.

3. Real-Time Detection: The system provides immediate object detection without processing delays.

4. Scalable Design: Additional sensors can be integrated to expand detection range..

5. Educational Value: Excellent learning platform for embedded systems and sensor technology.

6. Autonomous Operation: Operates independently enabling continuous surveillance.

7. Open-Source Flexibility: Unlimited customization and integration capabilities.

8. Practical Applications: Can be deployed in robotics, security, and navigation.

VI. APPLICATIONS

1. Autonomous Obstacle Avoidance: Robots detecting obstacles automatically in unknown environments.

2. Security Surveillance: Detecting unauthorized intrusions at entry points and restricted areas.

3. Parking Assistance: Detecting objects during vehicle parking with real-time distance information.

4. Collision Detection: Preventing collisions in manufacturing and robotics applications.

5. Range Measurement: Industrial distance measurements and level detection.

VII. CONCLUSION

In today's era of IoT and smart automation, the Arduino Radar Object Detection System demonstrates how accessible embedded systems technology can provide practical solutions for real-world applications. By combining affordable components with intelligent programming, the platform delivers accurate object detection comparable to expensive commercial systems. This project validates the effectiveness of Arduino-based solutions in surveillance and robotics applications, contributing to the democratization of advanced technology.

VII. ACKNOWLEDGMENT

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