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RADAR-BASED OBJECT DETECTION SYSTEM ON RC VEHICLE

Sulakshana Nishikant Bhatlawande[1], Rohit Santosh Gaikwad[2] ,Aniket Eknath Pangale[3]
Aditya Avinash Dalavi[4] , Naresh Satish Deshmukh[5] ,Krushna Shivaji Tagad[6]
[1]Lecturer, Department of E&C Engineering, Y.B.Patil Polytechnic, Akurdi, Pune
[2]Student, Department of E&C Engineering, Y.B.Patil Polytechnic, Akurdi, Pune
[3]Student, Department of E&C Engineering, Y.B.Patil Polytechnic, Akurdi, Pune
[4]Student, Department of E&C Engineering, Y.B.Patil Polytechnic, Akurdi, Pune
[5]Student, Department of E&C Engineering, Y.B.Patil Polytechnic, Akurdi, Pune
[6]Student, Department of E&C Engineering, Y.B.Patil Polytechnic, Akurdi, Pune

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ABSTRACT

This work describes the development and testing of an ultrasonic radar detection system integrated onto a Remote-Controlled (RC) vehicle chassis. The primary objective is identification of aerial objects including drones and low-altitude flyers using an HC-SR04 sensor positioned atop a servo-driven rotating mast. The vehicle platform is fabricated from foam board and features six wheels driven by four DC motors through a motor driver, governed by an Arduino Uno, two servo motors, and a 40 Hz RF transceiver pair. Servo 1 handles front axle steering while Servo 2 executes a continuous angular sweep of the mast across 15° to 165°. Angle and distance measurements are relayed via serial link to a PC where a Processing IDE application renders a graphical radar view. Wireless capability is added through the NodeMCU ESP8266, providing IoT-enabled remote data access. The outcome is an affordable, modular, and operational prototype suitable for radar-based proximity surveillance.

KEYWORDS:- *Radar System, Arduino Uno, HC-SR04 Ultrasonic Sensor, Servo Motor, RC Vehicle, Processing IDE, NodeMCU ESP8266, IoT, Drone Detection, Object Detection.*

I. INTRODUCTION

With the rapid spread of unmanned aerial vehicles (UAVs) across civilian and commercial sectors, new security vulnerabilities have emerged worldwide. These platforms can be exploited for illicit monitoring, contraband transport, or as tools of disruption near restricted facilities. This growing threat landscape underlines the demand for affordable, easily deployable radar systems capable of identifying such aerial objects.

Conventional radar installations are bulky, costly, and tailored for defence applications, making them unsuitable for small-scale or educational deployments. This project bridges that gap by building a miniaturised, Arduino-controlled radar unit mounted on a mobile RC chassis. The combined platform can traverse a target area while its onboard ultrasonic scanner continuously probes the surrounding space for any object appearing within a 40 cm radius.

The HC-SR04 acquires range data across a 15°–165° sweep and streams it to a Processing 3 radar display on a PC. IoT capability via the NodeMCU ESP8266 enables wireless data transmission.

The paper covers system design, construction, IoT integration, experimental results, and future directions.

II. NEED OF THE SYSTEM

The rising use of drones calls for accessible and affordable aerial monitoring. Key reasons for building this system include:

- Drone Threat Mitigation: Unauthorized drones threaten privacy and infrastructure; a mobile radar can quickly cover any area.
- Affordability: Using common parts like Arduino Uno, HC-SR04, and servo motors keeps costs very low.
- Portability: Mounting on an RC vehicle allows deployment across varied environments, unlike fixed radar systems.
- Learning Utility: Provides hands-on experience with embedded systems, sensor interfacing, and IoT.
- Real-Time Monitoring: The Processing GUI shows live radar imagery for instant detection.
- Scalability: Modular design allows easy upgrades to LiDAR or other sensors for real-world use.

III. LITERATURE SURVEY

1. A. Kumar et al., IEEE Sensors Journal – HC-SR04 sensors deliver consistent readings up to 400 cm within ±3 mm, confirming their suitability for close-range detection.
2. P. Sharma et al., Int. Journal of Robotics and Automation –Servo-driven ultrasonic sensors with Arduino yield an economical 180° scanning radar with reliable spatial maps.

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3. R. Patil et al., IoT and Cloud Computing Research Journal –ESP8266 NodeMCU provides reliable, low-latency wireless transfer of sensor data for real-time IoT monitoring.

IV. SYSTEM DESIGN AND FUNCTIONING

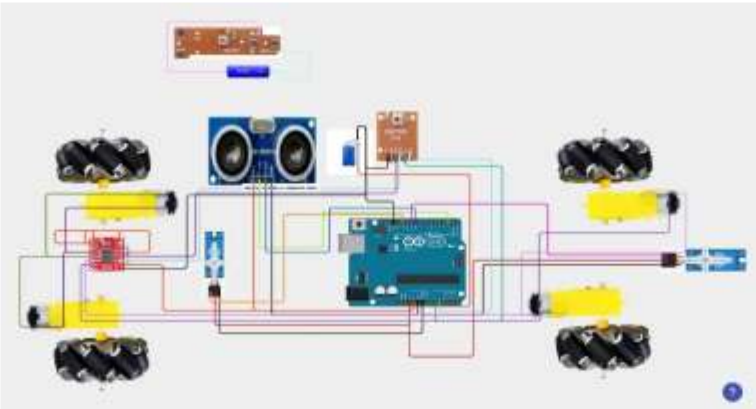
A. System Overview

The complete system comprises four tightly coupled subsystems: the motorised RC drive platform, the angular scanning radar assembly, the Arduino-based control core, and the PC-side visual interface. The Arduino Uno functions as the master controller, orchestrating both servo motor movements and HC-SR04 sensor readings while relaying processed data to the connected computer.

Vehicle manoeuvrability is achieved through a 40 Hz RF transceiver pair. The receiver outputs for right (R) and left (L) steering connect to Arduino analog pins A0 and A1, letting the microcontroller decode directional commands and actuate Servo 1 accordingly. The forward (F) and backward (B) lines from the receiver feed straight into the motor driver, governing propulsion without Arduino intermediation.

Servo 2 advances the mast in 5° increments across the 15°–165° band. At every angular stop, the HC-SR04 emits a 10 μs trigger pulse and times the reflected echo to derive the range. The resulting angle-distance tuple is then pushed over the serial interface at 9600 baud to a PC running the Processing 3 radar application.

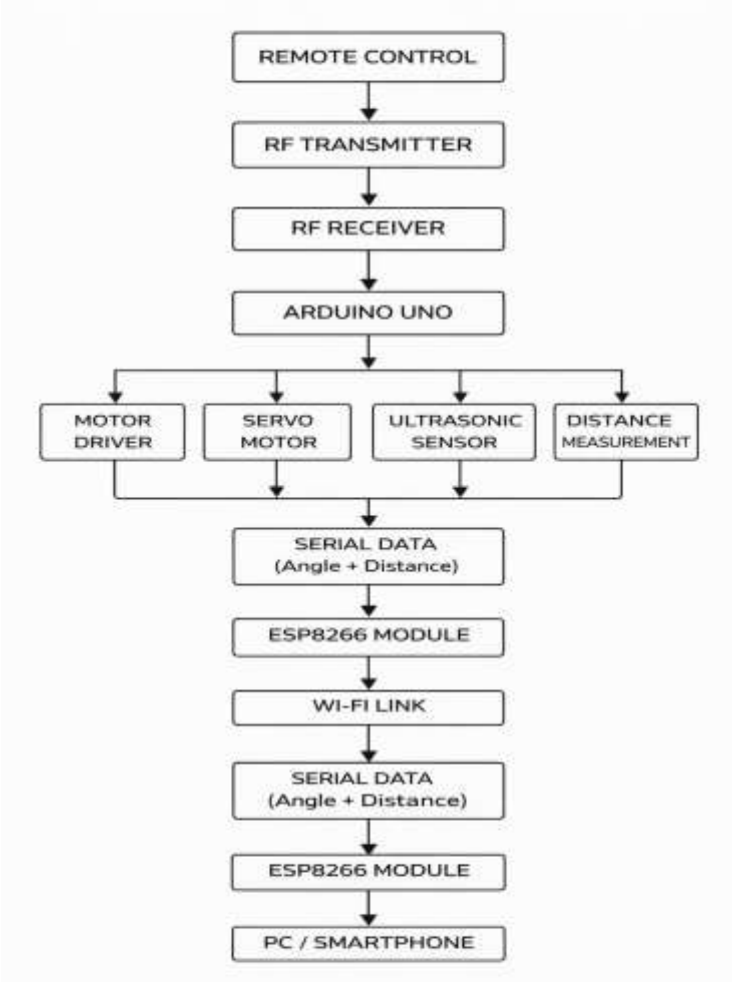
Fig. 1: Complete Circuit Diagram of the Radar RC Vehicle (Cirkit Designer)



B. Block Diagram Description

The system block diagram consists of the following interconnected modules:

- RF Receiver Module (KQF33R) → Arduino Uno Analog Pins (A0, A1) for steering input
- RF Receiver Module → Motor Driver (IN1-IN4) for forward/backward motor control
- Motor Driver → 4x DC Motors (rear wheels) for vehicle propulsion



- Arduino Uno (Pin 10) → Servo 1 → Front wheel steering mechanism
- Arduino Uno (Pin 12) → Servo 2 → Radar mast rotation
- Arduino Uno (Pin 2/9) → HC-SR04 Ultrasonic Sensor (Trig/Echo)
- Arduino Uno (USB Serial) → PC Running Processing 3 → Radar GUI Display
- NodeMCU ESP8266 → Wi-Fi → Remote PC (IoT Integration)
- 18650 Li-ion Battery Pack → VIN of Motor Driver → Power Supply

V. CONSTRUCTION

Assembling the radar RC vehicle required the following sequential stages:

1. Vehicle Body: The truck-style body was shaped from foam board sheets. A driver cab was built at the front and a flat deck at the rear provided space for all electronics. Rectangular window apertures were covered with blue tinted film for a realistic look, and white LEDs were fixed at the front to serve as headlights.

2. Wheel and Motor Assembly: Four DC gear motors were secured at the four corners of the rear deck using foam board mounts. Yellow plastic wheels fitted with rubber tyres were pressed onto each motor axle. Motor pairs were connected to the corresponding output terminals on the motor driver board.

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3. Front Steering Mechanism: A pair of wheels at the front were connected through a mechanical linkage to Servo 1, which is wired to Arduino pin 10 and positioned centrally between the front axles. The servo rests at 84° for straight-ahead travel, rotates to 60° for left turns, and to 120° for right turns.

4. Radar Mast Assembly: A wooden dowel rod was erected vertically on the cargo deck to form the radar mast. Servo 2 (connected to Arduino pin 12) was secured at its base to provide rotational drive. The HC-SR04 sensor was fastened at the top in a forward-facing orientation, allowing it to sweep the airspace ahead as Servo 2 turns.

5. Electronics Assembly: The Arduino Uno, breadboard, and motor driver were affixed to the cargo deck. The 18650 Li-ion cell pack was placed in the rear enclosure. All inter-component wiring used standard jumper leads. The RF receiver was positioned separately with its antenna wire routed for maximum signal coverage.

6. Power Supply: The 18650 Li-ion pack feeds directly into the motor driver VIN rail. During development, the Arduino receives power over USB; in standalone operation it draws regulated 5 V from the motor driver output.

VI. INTERNET OF THINGS (IoT) INTEGRATION

The NodeMCU ESP8266 bridges sensor data from the vehicle to a remote PC over Wi-Fi, removing the USB cable constraint.

A. Role of NodeMCU ESP8266

It receives angle and distance values from the Arduino via UART and relays them wirelessly to the Processing client.

B. Communication Architecture

- Arduino Uno → Serial UART → NodeMCU ESP8266 (data reception at 9600 baud)
- NodeMCU ESP8266 → Wi-Fi (802.11 b/g/n) → Local Network Router
- PC (Processing IDE) → Wi-Fi → NodeMCU TCP/UDP Socket → Radar Data

C. Benefits of IoT Integration

- Removes the USB cable, giving the vehicle full freedom of movement.
- Any networked device can view live radar data without extra hardware.
- Future updates could add cloud forwarding (e.g., ThingSpeak) for data storage.
- Multiple clients can connect to the ESP8266 simultaneously.

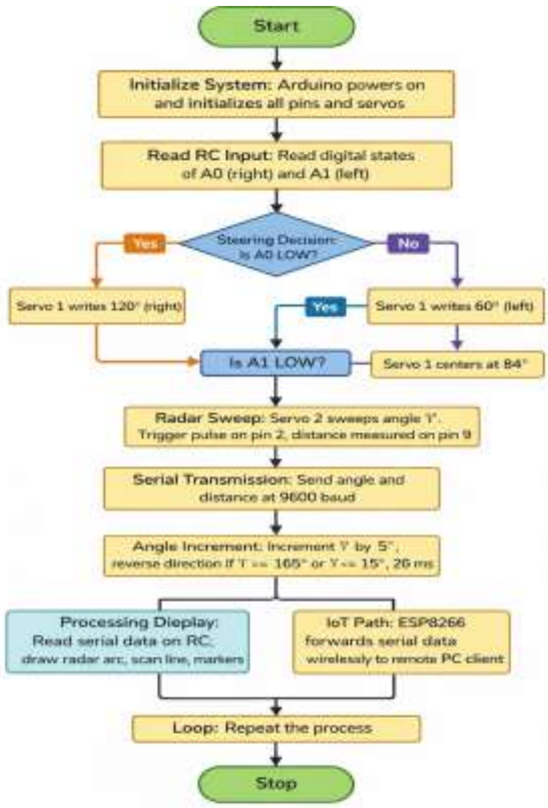
The ESP8266 is programmed via Arduino IDE; it connects to Wi-Fi, opens a TCP port, and relays ‘angle,distance.’ packets to clients.

VII. DATAFLOW DIAGRAM AND SAMPLE CODE

Dataflow Diagram:

The dataflow of the system proceeds as follows:

- Step 1 — Start: System powers on; Arduino initializes all pins and servos.
- Step 2 — Read RC Input: Arduino reads digital states of analog pins A0 (right) and A1 (left) from the RF receiver.
- Step 3 — Steering Decision: If A0 is LOW → Servo 1 writes 120° (right). If A1 is LOW → Servo 1 writes 60° (left). Else → center at 84°.
- Step 4 — Radar Sweep: Servo 2 writes current angle 'i'. Trigger pulse sent on pin 2. Echo time measured on pin 9. Distance calculated (cm).
- Step 5 — Serial Transmission: Angle and distance sent as 'angle,distance.' string over Serial at 9600 baud.
- Step 6 — Angle Increment: i += stepVal (5°). If i >= 165 or i <= 15, stepVal reverses direction. Delay 20 ms.
- Step 7 — Processing Display: Processing reads serial data, extracts angle and distance, and draws radar arc, scan line, and object marker on PC screen.
- Step 8 — IoT Path (parallel): ESP8266 receives same serial data and forwards wirelessly to remote PC client.
- Step 9 — Loop: Return to Step 2.
- Step 10 — Sto



VIII. WORKING

On power-up, the Arduino initializes serial, servos, and HC-SR04 pins; Servo 1 centers at 84°.

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RF Control: The KQF33R receiver outputs F/B/R/L signals. F and B drive motors directly; R and L are read by Arduino pins A0/A1.

Steering: Servo 1 writes 120° (right), 60° (left), or 84° (center) based on R/L input.

Radar Sweep: Servo 2 sweeps 15°–165° in 5° steps; HC-SR04 pulses at each stop and computes distance as (duration × 0.034) / 2.

Each angle-distance pair is sent at 9600 baud; Processing 3 parses and updates the radar display every 20 ms.

Radar Display: The Processing application renders a half-circle radar screen (green arcs). A green scan line rotates to match the current angle. When an object is detected within 40 cm, a red line segment is drawn at the object's position on the radar. Object status ('Object Detected' or 'Out of Range'), current angle, and distance are displayed at the bottom.

IX. RESULT

The integrated radar detection platform was built, assembled, and subjected to systematic evaluation. Key observations from testing are summarised below:

- The HC-SR04 sensor reliably identified targets across a 2 cm to 40 cm window, and corresponding detections were rendered accurately on the radar display.
- Servo 2 executed a steady, repeatable scan arc between 15° and 165° in both directions, exhibiting negligible positional jitter attributable to the 20 ms inter-step pause.
- The Processing 3 radar screen updated fluently, drawing the rotating scan beam, object highlights, and alphanumeric readouts with low latency and good visual clarity.

X. ADVANTAGES

Low Cost: Built with off-the-shelf parts (Arduino Uno, HC-SR04, servo motors) at minimal cost — ideal for education and research.

Mobility: Vehicle-mounted design enables flexible deployment across varied terrains.

Real-Time Visualization: Processing GUI shows detected objects with live angle and distance data.

IoT Enabled: ESP8266 enables wireless remote monitoring without a USB connection.

Modular Design: Independent subsystems simplify maintenance and upgrades.

Educational Value: Covers embedded systems, servo control, sensing, serial communication, graphical programming, and IoT.

XI. CONCLUSION

This study has successfully realised a compact radar detection unit embedded within a remote-controlled vehicle. By combining an Arduino Uno controller with an HC-SR04 sensor, dual servo motors, a motor driver, and an RF transceiver module, the design unifies platform mobility and continuous radar surveillance into one coherent system.

XII. FUTURE ENHANCEMENT

- Autonomous Navigation: Integrate GPS and obstacle avoidance algorithms to enable the vehicle to navigate autonomously while scanning, without requiring manual RF control.
- Machine Learning: Implement a classification model to distinguish between different types of aerial objects (drones, birds, projectiles) based on their radar signatures.
- Camera Integration: Add a pan-tilt camera module synchronized with the radar to visually confirm detected objects, providing a dual-sensor detection system.
- Mobile App Interface: Develop a dedicated mobile application that displays the radar data in real-time, receiving data from the ESP8266 over Wi-Fi, making monitoring possible from any smartphone.

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