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High Radio Frequency-Based RC Wheeled Robot For Defense Application

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Abstract

This paper presents the design and development of a high-frequency RF-controlled wheeled robot tailored for defense and tactical field applications. The system integrates a diverse set of actuators, sensors, and embedded controllers to enable long-range mobility, real-time surveillance, and missile-launching functionality. The robot employs four Johnson quad-encoder motors for precise locomotion, supported by additional gear motors and TowerPro servo motors for directional and payload control. A GPS module and dual Raspberry Pi cameras—standard and night-vision—provide enhanced navigation and continuous monitoring. Communication is facilitated through a Bluetooth Module wireless transceiver, ensuring stable and secure RF transmission. The architecture incorporates two Arduino Uno microcontrollers, dedicated to motor regulation and missile deployment, respectively, while a Raspberry Pi 3 handles live video streaming. Experimental results demonstrate robust RF communication, lowlatency visual feedback, and modular control performance, validating the robot's effectiveness for remote defense operations.

Keywords: Unmanned Ground Vehicle (UGV), RF Communication, Arduino Uno, Raspberry Pi 3, Encoder Motors, Servo Motors, Missile Launching System, Real-Time Video Streaming, GPS Module, Ultrasonic Sensors, Defense Robotics, Remote Surveillance

1. Introduction

Unmanned ground vehicles (UGVs) play an increasingly important role in modern defense operations, providing support in surveillance, reconnaissance, and remote payload deployment. Conventional control methods using Wi-Fi or GPS can become unreliable in combat environments, making high-frequency RF communication a more secure and robust option for remote operation.

To address these challenges, this project presents a high-frequency RF-based RC wheeled robot designed for defense use. The system employs a multi-microcontroller architecture consisting of two Arduino Uno boards—one for motor control and another for missile launching—and a Raspberry Pi 3 dedicated to real-time video streaming. The robot uses Johnson quad encoder motors, gear motors, and TowerPro MG946R servo motors to achieve precise movement and controlled missile actuation. A standard 5MP camera and night-vision module allow continuous monitoring in both daylight and low-light conditions.

Additional components such as a GPS module, ultrasonic sensors, and a Bluetooth Module transceiver ensure accurate tracking, obstacle detection, and stable RF communication. The entire system is powered through a step-down module and housed in a durable electronic-grade metal chassis.

The main objective of this work is to develop a reliable, RF-controlled UGV capable of remote mobility, surveillance, and payload operations, enhancing safety and operational efficiency in defense missions.

2 Methodology

The development of the RF-based RC wheeled defense robot followed a systematic methodology involving hardware integration, communication design, software development, and system testing. The major stages are outlined below.

2.1 Hardware Integration

All mechanical and electronic components were assembled onto an electronic-grade metal chassis.

- Locomotion Unit: Four Johnson quad encoder motors and gear motors were interfaced through motor driver modules to enable forward, reverse, and turning movements.
- Missile Launcher Unit: High-torque TowerPro MG946R servo motors were used to actuate the launcher.
- Surveillance Unit: A standard 5MP Raspberry Pi camera and a night-vision camera module were mounted for continuous monitoring.
- Navigation and Sensing: A GPS module was connected for position tracking, and ultrasonic sensors were placed for obstacle detection.
- A step-down power supply module was used to regulate voltage and protect components.

2.2 Communication Setup

The robot's control system uses a Bluetooth Module transceiver module for long-range RF communication. The transmitter side sends motion and launcher commands, while the receiver module on the robot interprets these signals through the respective Arduino boards. RF-based control ensures stable communication even in environments where Wi-Fi or GPS signals may be unreliable.

2.3 Software Development

- Arduino IDE and Python were used to program all controllers.
- The motor-control Arduino processes RF input to drive motors and manage speed using encoder feedback.
- The launcher-control Arduino handles servo motor commands for missile deployment.
- The Raspberry Pi runs a Python script for real-time video capture and live streaming to the user interface.Model Selection

2.4 System Integration and Testing

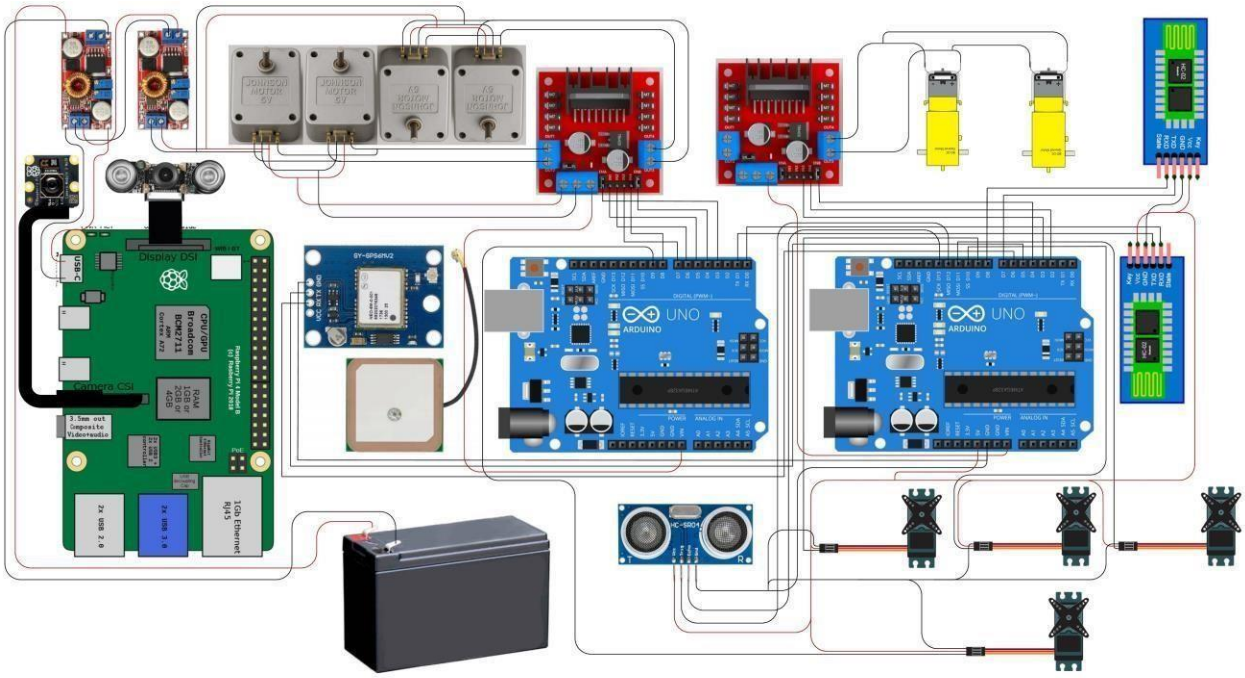
After assembling hardware and uploading firmware, all subsystems were interconnected and tested for coordinated operation. Testing included:

- RF communication range tests
- Motor precision and movement stability
- Missile launcher actuation accuracy
- Day and night video streaming quality

- GPS accuracy and ultrasonic sensor responsiveness

The complete robot was then evaluated under various terrain and lighting conditions to validate its performance for defense applications.

2.5 System Architecture



The system architecture of the RF-based RC wheeled defense robot is built on a modular, multi-controller design that integrates control, sensing, actuation, and communication. Two Arduino Uno boards divide the core functions: one manages locomotion by controlling Johnson encoder motors and gear motors through L298N motor drivers, while the other operates TowerPro servo motors for missile launching. A Raspberry Pi handles real-time video streaming using both a standard camera and a night-vision module. The robot is equipped with a 2.4 GHz RF transceiver for long-range wireless communication, a GPS module for position tracking, and an ultrasonic sensor for obstacle detection. All components are powered by a rechargeable battery with a step-down regulator to ensure stable voltage, resulting in a robust and reliable architecture suitable for defense applications.

2.6 Workflow

Command Transmission: The operator sends movement or missile-launch commands through the 2.4 GHz RF remote controller.

Signal Reception: The RF receiver on the robot forwards commands to two Arduino Uno boards—one for motor control and one for missile launching.

Locomotion Control: The motor-control Arduino drives Johnson quad encoder motors and gear motors through motor drivers to execute movement.

Missile Launching: The launcher-control Arduino operates TowerPro MG946R servo motors to position and trigger the missile launcher.

Real-Time Video Feedback: A Raspberry Pi 3 captures live video using a 5MP camera and a nightvision module, streaming it back to the operator.

Navigation & Sensing: GPS provides location tracking, while ultrasonic sensors detect obstacles for safer navigation.

Power Management: A step-down module supplies stable voltage to all electronic components**.**

Continuous Control Loop: Video feed and sensor data help the operator adjust commands, ensuring smooth and responsive robot operation

2.7 Implementation Tools

Category	Tools / Frameworks Used
Microcontrollers	Arduino Uno (2), Raspberry Pi 3
Actuators	Encoder Motors, Gear Motors, Servo Motors
Motor Drivers	L298N Modules
Communication Module	2.4 GHz RF Transceiver
Sensors	GPS Module, Ultrasonic Sensor
Cameras	5MP Camera, Night Vision Camera
Power Supply	Battery, Step-Down Regulator

2.8 Conclusion

This project successfully demonstrates the design and implementation of a high-frequency RF-based RC wheeled robot capable of remote mobility, surveillance, and missile launching for defense applications. By integrating multiple microcontrollers, encoder-based motors, servo mechanisms, and real-time video streaming, the system provides reliable operation in environments where traditional communication methods may fail. The use of GPS and ultrasonic sensors further enhances navigation and situational awareness. Overall, the robot offers a robust, modular, and cost-effective solution for tactical defense operations, improving safety and operational efficiency for field personnel.

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