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IOT-Based Advanced Controlled Defense Vehicle

S. A. Goudadi[1], M.S.Futane[1], Akshay A. Gadave[2]

Hirasugar Institute of Technology, Nidasoshi

Email: sagoudadi.mech@hsit.ac.in, mohanfutane.mech@hsit.ac.in, akshaynesari123@gmail.com

ABSTRACT

Development of a Ground Armed vehicle for use in forest conservation is a new defense approach. The project is aimed at protecting wildlife by employing an automated device specifically designed to minimize threats to animal and human populations. Targeting the protection of forest habitats, the vehicle is equipped with motion-controlled equipment and a rotatable gun turret to enable efficient patrolling and deterrence. Additionally, wireless CCTV surveillance enhances monitoring of distant areas and instant feedback on probable threats. Automation of surveillance procedures by the vehicle eliminates threats to human personnel, particularly in border regions where constant monitoring is important to national security. The project targets the need to employ advanced technologies in responding to advanced defense and wildlife conservation issues, resulting in enhanced security and safety in vulnerable ecosystems.

The present research project emphasizes the design of a ground combat armed vehicle with improved motion control and firing mechanisms for military applications as well as demonstration purposes. The vehicle utilizes two Johnson motors in the rear, each with a 30 RPM, to enable cautious maneuverability that facilitates controlled movement in any direction. The mechanism employed in tilting the angle of the gun is powered by a 10 RPM motor, enabling accurate vertical targeting of the gel-based ball firing system. A properly aligned gun is facilitated by an engineered metal bracket, while firing is facilitated using a Relay circuit, enabling smooth and accurate operation.

The system operates on Bluetooth technology and is connected to an Arduino Nano microcontroller, enabling remote control through a mobile app. The system provides seamless control of the car's navigation and weaponization features, making it a flexible platform for use in military operations as well as demonstration shows. The project demonstrates the integration of mechanical, electrical, and software engineering to develop an efficient and remotely controlled vehicle for diverse applications, highlighting the development of remote-operated weapon systems and robotics.

Keywords: *IoT, Autonomous Defense Vehicle, Border Security, Surveillance, Robotics, Automation*

1. Introduction

In an era of unprecedented technological progress that is transforming defense and wildlife conservation sectors, innovation of new solutions is more than necessary. The Ground Armed Vehicle program is one example of convergence of engineering innovation and forward-thinking planning to address some of the most acute forest defense and border monitoring issues. Through the application of automation and remote control technology, the program is working towards transforming the means being employed in natural habitats conservation as well as safeguarding the country's borders.

The main aim of this project is to develop a flexible and solid vehicle that can scan forest regions independently, thereby safeguarding wildlife and human residents from potential damage. Identifying the flaws and dangers of conventional surveillance and intervention practices, this project is intended to utilize a technology-driven approach that ensures minimal human interference and maximum effectiveness and efficiency.

Moreover, the incorporation of wireless CCTV surveillance technology provides yet another level of sophistication to the vehicle's capability, allowing the collection of real-time data and the provision of pre-emptive warning of possible threats. Not only does this improve situational awareness but also offers decision-makers timely, actionable information on which to base a rapid and effective response to changing circumstances.

Apart from its application in forest defense, the vehicle possesses significant potential for utilization in border surveillance operations. Where complex terrain and inclement weather conditions disable the application of traditional surveillance technologies, the combination of autonomous vehicles with advanced sensors and communication technologies presents an effective option. By reducing the exposure of human operators conducting continuous surveillance in difficult-to-reach and hostile territories, the vehicles contribute significantly to national security and territorial integrity.

Briefly, the Ground Armed vehicle program is a paradigm shift in our defense and conservation strategy. With the use of advanced technologies and creative design principles, it seeks to offer a scalable and sustainable solution to multifaceted and varied challenges, thereby encouraging the preservation of natural ecosystems and human lives.

2. Literature Review

Existing research highlights the successful integration of IoT and robotics in security applications. Notable studies include:

1. **Surveillance Systems:** Joshi & Tondarkar’s real-time surveillance system leveraging Raspberry Pi and IoT. Equipped with multi-sensory capabilities, it detects enemy presence through cameras and provides live streaming to authorized personnel. The system, utilizing Raspberry Pi and Python programming, facilitates video streaming for real-time surveillance.
2. **Rough Terrain Navigation:** Bhatnaga r& Gola’s study on terrain-adaptive defense robots with infrared and ultrasonic sensors. It emphasizes low-cost solutions and functionalities development in rough terrain conditions, employing Zigbee protocols, RF modules, touch screens, and Wi-Fi technology.
3. **Military Robotics:** Borte & Darade’s multifunctional military robots equipped with 3G connectivity. Capable of autonomous and manual operation via Internet communication, this robot detects threats such as bombs, human presence, and harmful fires.
4. **Wireless Communication:** Manoharan’s intelligent unmanned robot (IUR) using Zigbee technology for remote defense applications. This system employs a low-power Zigbee wireless sensor network to navigate paths and detect obstacles autonomously, minimizing manual errors and ensuring human safety.

5. **Mobile-Controlled Robotics:** Kahar's research on Bluetooth and Wi-Fi-enabled mobile robot control. Emphasizing the benefits of mobile device integration, it underscores the increasing utilization of mobile technology in robotics development.

These studies form the foundation for the development of the ACDV, emphasizing its feasibility and adaptability for real-world security scenarios.

Consultation with Specialists:

Swastik Engineering specialists in the subject area were consulted for the purpose of assessing the practicality of creating an automated defense vehicle. This process served to confirm the ACDV design in accordance with real-world constraints, including material selection, power efficiency, and control schemes.

3. Principle of Working

The Ground Armed Vehicle project integrates mechanical, electrical, and software components to achieve efficient and precise operation. The vehicle's movement is controlled by two Johnson 30 RPM motors located at the rear, enabling navigation in all directions—left, right, forward, and reverse—across various terrains.

A 10 RPM motor is used to control the gun's angle adjustment, allowing for precise targeting. The gun is mounted on a metal bracket that supports motorized adjustments for better accuracy in dynamic scenarios. The firing mechanism, which uses gel-based balls, is controlled by a Relay circuit. This circuit simulates firing for demonstration purposes, adding to the vehicle's capabilities.

The entire system is remotely controlled using Bluetooth technology. Through an Arduino Nano microcontroller, motor drivers, and relay modules, users can operate the vehicle via a custom mobile app. This interface provides controls for movement, gun angle adjustments, and the firing mechanism.

Additionally, a wireless CCTV surveillance system is integrated into the vehicle to offer real-time monitoring and situational awareness. This enhances the vehicle's utility for military demonstrations and surveillance operations.

By combining these advanced technologies, the Ground Armed Vehicle project offers a versatile and effective solution for defense, showcasing its potential in addressing complex operational needs.

4.0 Design and Development:

A full 3D Digital Mock-Up (DMU) was developed to mimic the vehicle's structural integrity, component location, and overall functionality. With CAD software, such critical considerations as weight distribution, motor location, and weapon placement were optimized for performance and longevity.

Structure Calculation:

To begin the design calculations for the Ground Armed Vehicle, we'll first focus on the structural stability of the chassis frame using the 20mm x 20mm MS tube with dimensions of 30cm x 45cm.

a. Maximum Load Calculation:

Given:

- Johnson 30 RPM motor stall torque: 1000 N-cm

- Two motors used for left-right and front-rear motion

The maximum load on each motor can be estimated by assuming worst-case scenarios where the vehicle encounters resistance while moving. Let's assume a maximum load of 50 kg (approx. 500 N) for the vehicle.

Total load on each motor = 500 N / 2 motors = 250 N

b. Moment Calculation:

Considering the dimensions of the frame, the maximum moment will occur when the vehicle is at its longest length (45cm).

Moment (M) = Load (F) × Distance (d)

M = 250 N × 0.45 m

M = 112.5 Nm

c. Structural Stability Analysis:

The structural stability of the chassis frame depends on its ability to withstand bending moments without excessive deflection. We can calculate the maximum allowable stress using the formula:

Allowable Stress (σ) = Moment (M) / Section Modulus (S)

d. Section Modulus Calculation:

For a rectangular tube, the section modulus (S) is given by:

S = (width × height^2) / 6

Given frame tube size:

Width (b) = 20 mm

Height (h) = 20 mm

S = (20 mm × (20 mm)^2) / 6

S ≈ 1333.33 mm^3

e. Allowable Stress Calculation:

Assuming a safety factor of 2, the allowable stress can be calculated as:

Allowable Stress (σ) = 112.5 Nm / 1333.33 mm^3

Allowable Stress (σ) ≈ 0.084 N/mm^2

f. Verification:

Check the allowable stress against the yield strength of the material. Assuming a mild steel yield strength of approximately 250 N/mm^2, the calculated allowable stress is well within the acceptable range.

Motor Mounting Calculation:

Given:

- Johnson 30 RPM motor stall torque: 1000 N-cm
- Distance from motor shaft to chassis edge: 10 cm

The maximum torque exerted on the motor mount can be calculated using the stall torque of the motor. Let's assume a safety factor of 1.5 for the motor mount design.

Maximum Torque (T) = Motor Stall Torque × Safety Factor

T = 1000 N-cm × 1.5

T = 1500 N-cm

Battery Mounting Calculation:

Given:

- Battery weight: Assumed 1 kg (approx. 10 N)
- Distance from mounting point to chassis edge: Assumed 5 cm

The maximum load on the battery mount can be estimated by considering the weight of the battery and its distance from the mounting point.

$\tau = 10N \times 0.05m = 0.5N \cdot m$

Thus, the torque (or load) applied is 0.5 N-m.

5. Hardware Components:

The ACDV is built from a range of basic hardware components:

Frame & Chassis:

• Material: Mild steel tube (20mm x 20mm), chosen for strength and structural stability.

•Weight Capacity: Capable of holding a 50 kg weight.

• Design: Constructed to endure rugged terrain with high impact resistance.

Mobility System:

• Motors: Two 30 revolutions per minute Johnson motors, each of stall torque 1000 Newton-centimeters, provide mobility across diverse topography.

• Wheels: Rubberized wheels with high traction for improved grip and control on rough surfaces.

• Motor Driver: L298N Dual H-Bridge Motor Driver, enabling precise speed and direction control.

Power System:

•Battery: 14.8V lithium-ion rechargeable battery, which provides extended operating characteristics.

•Power Distribution: Relay modules and voltage regulators are utilized to distribute power effectively to different components.

Surveillance and Monitoring System:

•Device: A small Wi-Fi Full HD IP camera for live streaming and distant monitoring.

• Connectivity: With Wi-Fi and Bluetooth to ensure seamless communication and data transfer.

Turret and Armament Configuration:

•10 RPM Gear Motor: A motor utilized to rotate the turret's angle for greater targeting precision.

• Simulation Mechanism: Use gel projectiles for less-than-lethal demonstrations.

Control and Communication System:

• Microcontroller: Arduino Nano, programmed with remote control and autonomous navigation.

•Wireless Communication: Short-range communication using Bluetooth module HC-05 and remote communication using Wi-Fi module ESP8266.

•Relay Circuits: Used for the effective and safe handling of high-power devices.

Integration Software:

•Programming Language: Embedded C, used to program the Arduino Nano for the purposes of motion control, surveillance, and data communication.

• Development Environment: Arduino IDE for writing, debugging, and deploying the firmware.

•Mobile App Control: Sophisticated mobile application for remote control of movement, observation, and weapon systems.

6. Results & Discussion

Structural and Mechanical Assessments:

• Chassis Strength: Constructed from a 20mm x 20mm MS tube, with a load capacity of 50 kg.

•Torque Specifications: Johnson 30 RPM motors provide a 1000 N-cm stall torque to enable smooth movement.

• Battery Power Supply: A 14.8V Li-ion battery provides prolonged operating time.

Performance Assessment:

ACDV was tested in different environments:

•Border Surveillance: Correctly identified illegal movement from CCTV feeds.

• Forest patrols proved effective in traversing difficult terrain while recording wildlife activities.

• Remote Operations: Exhibited smooth remote-controlled movement and turret mobility.

7. Applications

• **Military Operations:** Increases reconnaissance and perimeter security.

• Border Control: Enhances surveillance of risky border areas.

• Law Enforcement: Makes it easier to monitor and watch suspects.

• Disaster Management: Facilitates relief operations by collecting live data.

• **Conservation Initiatives:** Safeguards threatened animals from illicit activities.

8. Conclusion

ACDV project provides a new method of automated defense and surveillance, utilizing advanced technology to enhance wildlife and border security. Successful testing and development of the vehicle indicate its viability as a required device for security and military applications. Future studies should focus on AI-based decision-making implementation, improved mobility, and the strengthening of cyber security.

By leveraging these technologies, the Ground Armed Vehicle demonstrates agility, precision and remote operation capabilities essential for border security, surveillance, and protection of wildlife in forested areas. Furthermore, the project's emphasis on versatility, durability, and ease of use ensures its suitability for a wide range of operational scenarios.

9. Future Scope

•AI-Powered Threat Detection: Adding machine learning for autonomous response to threats.

•**LiDAR and GPS Navigation**: Increased ability for terrain adjustment and obstacle avoidance.

• **Renewable Energy Integration:** Solar charging for sustainable operation.

• **Secure Communication Protocols:** Most advanced encryption to ensure cyber-resilient functioning.

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