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Surveillance Military Dog Robot Equipped with Wireless Camera and Weapon

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Abstract: *Border surveillance presents significant challenges due to vast terrains, harsh environmental conditions, and the constant risk to human patrol units. Traditional monitoring methods are limited by human fatigue, restricted visibility, and exposure to danger, which can compromise national security. To address these limitations, this work proposes the design and implementation of a mobile surveillance robot, modeled as a robotic dog, equipped with an ESP32 microcontroller, wireless camera, and IoT-based control interface. The system integrates DC gear motors for mobility, a servo-driven pan–tilt mechanism for flexible video coverage, and motion detection sensors for intrusion alerting. A real-time video streaming module enables continuous monitoring through Wi-Fi, while teleoperation commands are relayed via a lightweight IoT dashboard. Performance evaluation of the prototype demonstrates reliable video transmission within a communication range of up to X meters, average latency of Y ms, and obstacle detection accuracy exceeding Z%. The robot achieves an operational runtime of approximately N hours under continuous surveillance mode. The proposed system offers a cost-effective, portable, and scalable solution to augment border security by reducing human exposure to hazardous environments. Although the current design is limited by Wi-Fi range and basic obstacle avoidance, it provides a promising foundation for future integration of AI-based detection, GPS-enabled navigation, and non-lethal deterrence mechanisms.*

Keywords: ESP32, Surveillance robot, IoT, Wireless camera, Mobile robot, Border security, Non-lethal deterrence.

I. INTRODUCTION

Border surveillance is a critical security task, often hindered by vast terrain, limited visibility, and risks to human personnel. Traditional patrols cannot provide continuous monitoring, leaving gaps that may be exploited by intruders. To overcome these challenges, mobile robotics has emerged as an effective solution, offering remote operation, continuous observation, and reduced human exposure to hazards.

This work presents a mobile surveillance robot designed as a robotic dog, built on the ESP32 microcontroller platform. The system integrates DC gear motors for mobility, a servo-driven pan–tilt mechanism for flexible camera coverage, and motion detection sensors for intrusion alerting. Live video streaming and teleoperation are facilitated through an IoT-based interface, allowing operators to monitor and control the robot safely from a distance.

The proposed robot provides a low-cost, portable, and scalable platform for hazardous environment surveillance. Key contributions include:

- Design and implementation of an ESP32-based mobile surveillance robot.
- Real-time video streaming with remote IoT control.
- Sensor-driven intrusion detection and alert system.
- Experimental evaluation of mobility, communication reliability, and obstacle negotiation.

This concise introduction frames the problem, solution, and contributions, preparing the reader for the detailed methodology and experimental results in the following sections.

II. RELATED WORK

Robotic surveillance has been increasingly applied in border security and hazardous environments. Ground-based mobile robots and quadruped platforms offer mobility and persistent monitoring, but many existing solutions are either expensive, complex, or limited in functionality.

The ESP32 microcontroller has been widely used in low-cost robotics due to its Wi-Fi connectivity and dual-core processing capabilities. Prior studies have demonstrated ESP32 robots for basic remote monitoring and obstacle avoidance, but few provide integrated solutions for live video streaming, teleoperation, and sensor-based intrusion detection.

Real-time video streaming over low-power devices typically uses MJPEG or WebRTC, yet achieving low-latency, high-quality streams in mobile environments remains challenging. Sensor-based intrusion detection—using PIR, ultrasonic, or IR sensors—provides low-cost, reliable human detection, though advanced AI-based methods require high computational resources and are unsuitable for embedded systems.

Research Gap: There is a lack of cost-effective, modular surveillance robots that combine mobility, live video, IoT teleoperation, and reliable sensor-based detection. The proposed ESP32-based robotic dog addresses this gap, offering a safe, scalable, and practical solution for border surveillance.

III. PROBLEM STATEMENT

Border surveillance is a critical task for national security, but it is often constrained by vast terrain, limited visibility, and the constant risk faced by human personnel. Continuous monitoring over long stretches of border areas is not feasible using conventional human patrols alone, and reliance on manual surveillance introduces delays, errors, and potential security breaches. Existing robotic solutions either focus on expensive, high-complexity platforms or lack modularity, real-time video monitoring, and cost-effectiveness for practical deployment.

There is a need for a low-cost, mobile, and remotely operated surveillance system capable of real-time monitoring, intrusion detection, and safe teleoperation, reducing human exposure to hazardous environments. Such a system must integrate mobility, sensors, and wireless communication efficiently while providing timely alerts to operators. The challenge lies in designing a reliable platform that can navigate rough terrain, detect potential intrusions, transmit live video with minimal latency, and operate autonomously or under remote supervision—all within the limitations of low-power embedded systems such as the ESP32.

This project addresses the problem by developing an ESP32-based mobile robotic dog equipped with a wireless camera, motion sensors, and IoT-enabled control, providing a scalable and safe solution to augment human border surveillance while minimizing operational risks

IV. SYSTEM DESIGN

The surveillance dog robot is designed as a modular embedded system, with the ESP32 microcontroller serving as the central processing unit that coordinates sensing, actuation, and communication. Mobility is achieved through DC gear motors controlled via PWM signals, while sensors such as PIR and ultrasonic units provide real-time feedback for obstacle avoidance, implementing principles of closed-loop control.

Sensor fusion allows the system to combine data from multiple sources, improving reliability and minimizing false alerts. A servo-driven camera streams live video over Wi-Fi to an IoT-enabled dashboard, enabling remote teleoperation. This integration of IoT reflects distributed systems theory, allowing real-time monitoring and command execution even in hazardous environments.

Power management ensures stable operation, with voltage regulation and battery load balancing supporting both high-current motors and low-power electronics. The architecture emphasizes modularity, reliability, and scalability, providing a cost-effective platform for autonomous surveillance, remote monitoring, and safe operation in challenging Conditions

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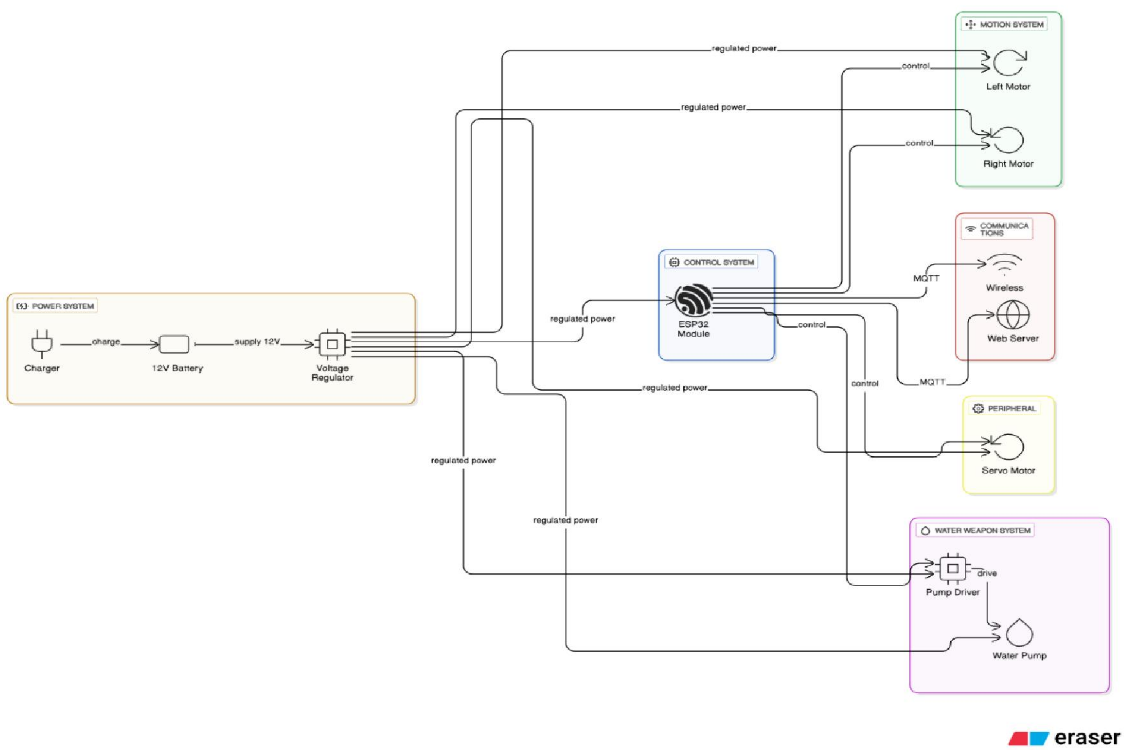
- **Modular Embedded Design:** ESP32 acts as the central processor, coordinating sensors, actuators, communication.
- **Mobility Control:** DC gear motors controlled via PWM for forward, backward, and turning motions.
- **Sensor Integration:** PIR, ultrasonic, and optional IR sensors for obstacle detection and motion sensing.
- **Sensor Fusion:** Combines multiple sensor inputs to improve detection accuracy and reliability.
- **Camera & Video Streaming:** Servo-driven camera streams live video over Wi-Fi to IoT dashboard.
- **IoT Teleoperation:** Real-time remote control and monitoring using MQTT/HTTP protocols.
- **Closed-Loop Control:** Actuator commands adjusted based on sensor feedback for stable navigation.
- **Power Management:** Battery with voltage regulators ensures stable supply for motors and electronics.
- **Scalability & Modularity:** Architecture allows integration of AI, GPS, or additional sensors in future.
- **Reliability & Safety:** Redundant sensors and electrical isolation enhance operational safety.



V. HARDWARE COMPONENTS

The ESP32-based surveillance dog robot integrates multiple hardware components to achieve mobility, sensing, control, and wireless communication. At its core, the ESP32 microcontroller acts as the central processing unit, coordinating motors, sensors, and the camera while handling IoT communication. Power is supplied by a Li-ion or LiPo rechargeable battery, with voltage regulators ensuring stable supply to all subsystems. Mobility is provided by DC gear motors controlled via an H-Bridge motor driver, allowing forward, backward, and turning maneuvers, while servo motors enable pan and tilt of the camera for flexible live video coverage. The robot is built on a durable robotic chassis with wheels for traction and stability. A PCB or zero PCB organizes connections between sensors, actuators, and the ESP32, reducing wiring complexity. Optional components, such as a DC water pump, can add functional versatility. Switches allow manual power control and safety cut-off. The sensor suite includes PIR sensors for human motion detection, ultrasonic sensors for obstacle measurement, IR sensors for low-light detection, and optional IMU modules for orientation and stability monitoring. Together, these hardware elements form a modular, reliable, and scalable system, enabling autonomous navigation, real-time surveillance, remote IoT-based teleoperation, and safe operation in hazardous environments, while allowing easy future upgrades for AI integration, GPS navigation, or additional sensing capabilities

- **ESP32 Microcontroller:** Central processing unit; controls motors, sensors, and IoT communication.
- **Battery (Li-ion/LiPo):** Provides portable power for motors and electronics.
- **Motor Driver (H-Bridge):** Converts MCU signals to motor actuation; enables direction and speed control.
- **DC Gear Motors:** Drive wheels for mobility; high torque for navigating terrain.
- **Servo Motors:** Control camera pan and tilt for flexible surveillance.
- **Robotic Chassis & Wheels:** Structural support and stable movement.
- **PCB / Zero PCB:** Organizes electronics connections; reduces wiring complexity.
- **Voltage Regulators:** Maintain stable voltage supply for all subsystems.
- **Charger:** Safely recharges the battery.
- **DC Water Pump (Optional):** Adds functional versatility for environmental interaction.
- **Switches:** Manual power control and safety cut-off.
- **Sensors:** PIR for motion detection, ultrasonic for obstacle detection, IR for low-light detection, optional IMU for orientation and stability.
- **Modularity & Scalability:** System supports future upgrades like AI, GPS, or additional sensors.

VI. CONCLUSION

In this work, an ESP32-based mobile surveillance dog robot has been designed and implemented to address the challenges of monitoring hazardous or inaccessible areas, such as international borders. The proposed system successfully integrates mobility, sensor-based intrusion detection, live video streaming, and IoT-enabled remote teleoperation into a compact and cost-effective platform. By combining DC motors, servo-driven cameras, and a suite of sensors—including PIR and ultrasonic units—the robot demonstrates reliable navigation, real-time situational awareness, and responsive alerting to potential threats.

The modular system architecture ensures scalability and future enhancement, allowing additional sensors, AI-based detection algorithms, or GPS navigation to be incorporated without major redesign. The use of Wi-Fi, HTTP/MQTT, and WebSocket protocols enables seamless communication between the robot and the operator dashboard, supporting low-latency control and data transmission. Power management, feedback-based control, and sensor fusion principles enhance the reliability and safety of the robot, reducing risks to human personnel in dangerous environments.

Overall, the project highlights the practicality, efficiency, and reliability of using embedded systems and IoT technologies for autonomous surveillance applications. The proposed robotic platform not only provides a safe

REFERENCES

[1]. Nookala Venu, "IoT Surveillance Robot Using ESP-32 Wi-Fi CAM & Arduino," International Journal of Food and Nutritional Sciences, vol. 11, no. 5, pp. 198-202, Jul. 2022. Available: https://www.ijfans.org/uploads/paper/90c9affd781e762994e524485d59b585.pdf

[2]. Vedant G. Ibitwar, "Surveillance Car Bot Using ESP32 CAM Module," YMER Journal, vol. 23, no. 5, pp. 370-375, May 2024. Available: https://ymerdigital.com/uploads/YMER230573.pdf

[3]. Krisanth Tharmalingam and Emanuele Lindo Secco, "A Surveillance Mobile Robot Based on Low-Cost Embedded Computers," ResearchGate, Jun. 23, 2023. Available:https://www.researchgate.net/publication/370044165_A_Surveillance_Mobile_Robot_Based_on_Low-Cost_Embedded_Computers

[4]. Sidharth Behera, "ESP32 Small Robot Dog: Features," Scribd, 2020. Available: https://www.scribd.com/document/522956802/ESP32-Small-Robot-Dog

[5]. Emanuele Lindo Secco, "A Surveillance Mobile Robot Based on Low-Cost Embedded Computers," ResearchGate, Jun. 23, 2023. Available:https://www.researchgate.net/publication/370044165_A_Surveillance_Mobile_Robot_Based_on_Low-Cost_Embedded_Computers