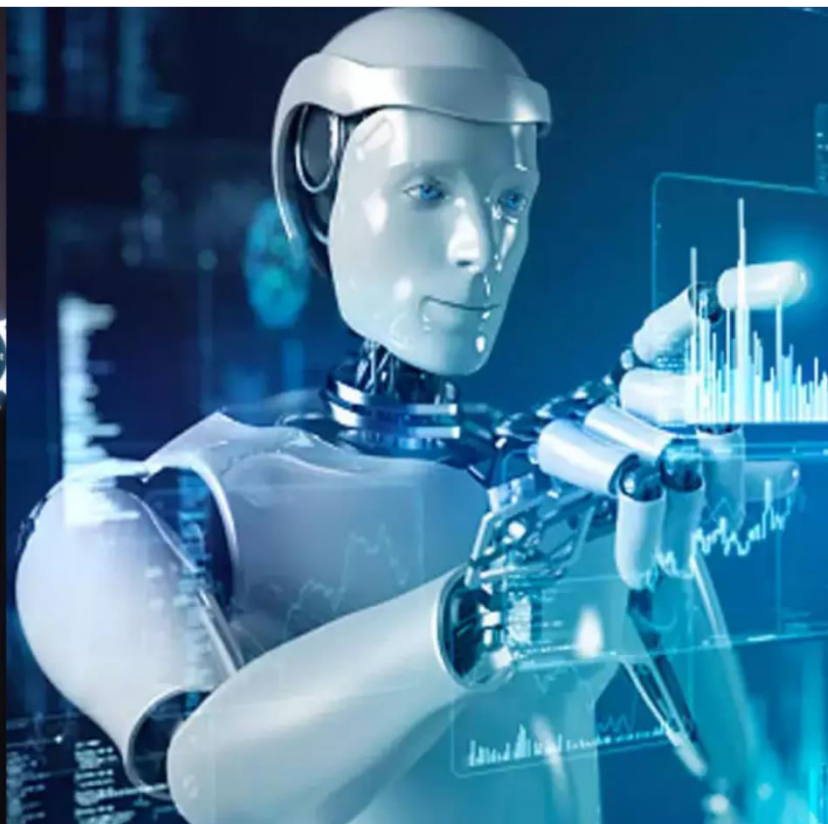




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Multi-Purpose, Remotely Operated Military Robot using Arduino and IoT Technologies

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ABSTRACT: This study introduces a versatile and cost-effective prototype of a remotely operated military robot for reconnaissance and threat response. Built around the Arduino Uno microcontroller, the system integrates environmental sensors and wireless control via Bluetooth. Real-time visual feedback is achieved using an ESP32-CAM module, while hazardous gas and metal detection modules enhance safety and awareness. Experimental results demonstrate stable operation with 95% detection accuracy and smooth mobility. The design bridges the gap between high-cost defense robotics and accessible research prototypes.

KEYWORDS: Arduino Uno, Wireless Control, ESP32-CAM, Gas and Metal Sensors, Military Robotics

I. INTRODUCTION

Military operations in hostile or unknown terrain require tools that decrease risk to human personnel while maximizing situational awareness. This work develops a multifunctional robotic system capable of remote surveillance, hazard detection, and simulated defense response. By employing an Arduino microcontroller with Bluetooth and Wi-Fi connectivity, the robot affords a user-friendly remote control interface combined with sensor-driven automated alerts. The platform's low-cost design makes it suitable for both research and tactical applications. High-end surveillance robots such as PackBot are expensive, limiting access for educational and tactical research use

II. LITERATURE REVIEW

Various robotic systems have been proposed employing independent features such as Bluetooth remote operation, IoT-based gas sensing networks, and video-streaming surveillance bots. Additionally, metal detection units have been utilized for mine detection. However, the integration of these capabilities into a singular, scalable design remains sparse. Our solution consolidates these systems to provide comprehensive functionality with affordability and scalability in mind. Recent advancements include AI-enabled reconnaissance bots and IoT-based battlefield monitoring systems

III. SYSTEM DESIGN AND COMPONENTS

The design integrates the following subsystems:

Motion Control: Dual-motor four-wheel drive operated through L293D motor drivers and managed by Arduino Uno, with commands issued via Bluetooth HC-05.

Visual Monitoring: ESP32-CAM module streams live video over Wi-Fi to a remote display device.

Gas Sensing: An MQ-2 gas sensor continuously evaluates air quality for flammable or hazardous gases, triggering alerts upon detection.

Metal Detection: A proximity sensor monitors for nearby metallic objects, enabling landmine or obstacle alerts.

Defense Simulation: A relay-actuated servo simulates weapon activation upon remote command or sensor triggers.

Operator alerts are transmitted promptly via Bluetooth communication.

Implementation Procedure

Development followed a modular

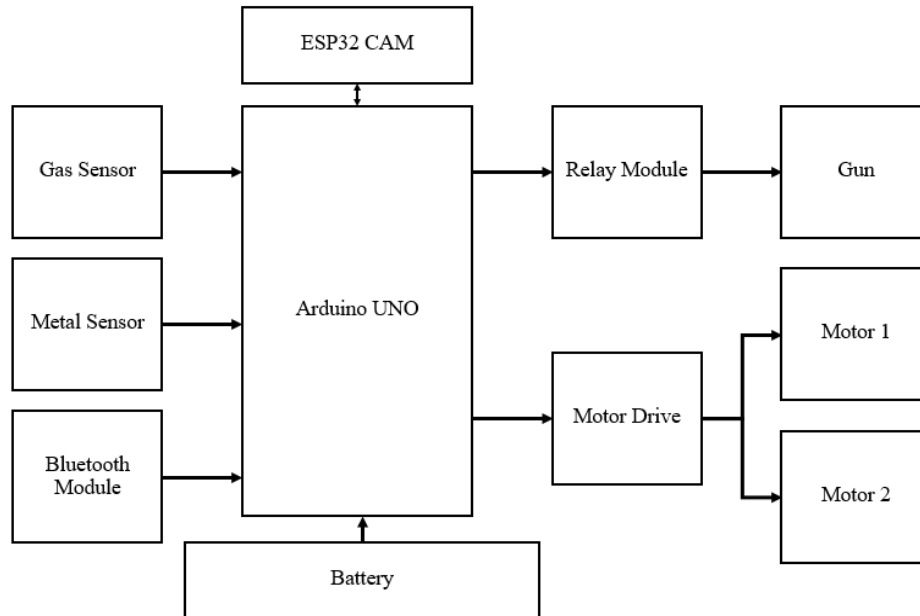


Figure1: Circuit schematic showing Arduino Uno connections with sensors and modules.

IV. METHODOLOGY

Hardware components were mounted on a compact chassis integrating motors, sensors, controllers, and communication modules.

The Arduino IDE facilitated programming for motion control, sensor readouts, and wireless communications.

Bluetooth pairing and Wi-Fi streaming were configured for seamless remote interaction.

Independent power lines supported uninterrupted operation of motors and sensors.

Testing consisted of navigation accuracy checks, sensor response validation, and video transmission quality assessments.

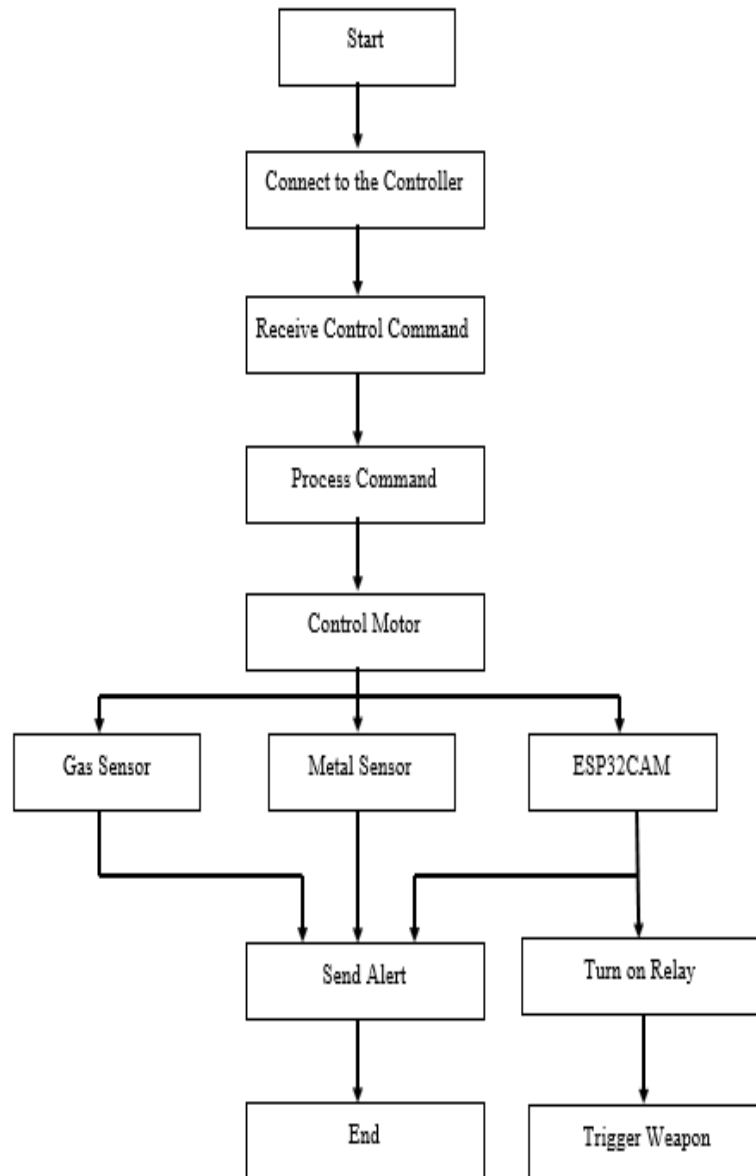


Fig.2. Flowchart of the robot operation and control algorithm

V. POTENTIAL APPLICATIONS

This robotic platform can serve in:

Military reconnaissance and border monitoring

Toxic hazard identification and emergency response

Search and rescue missions in perilous zones

Academic laboratories and robotics education

VI. EXPERIMENTAL OUTCOMES

The prototype exhibited reliable video streaming, sensor accuracy, and effective mobility under test conditions. Timely alerts were generated for gas and metal detections, and the simulated defense mechanism responded as expected. Limitations included Bluetooth signal range and battery longevity, suggesting enhancements for extended missions.



Fig.3. Prototype of the developed military robot.

VII. ADVANTAGES AND LIMITATIONS

Advantages: The system is low-cost, modular, capable of real-time alerts, wireless video streaming, and valuable as an educational platform.

Limitations: Bluetooth communication range is limited (~10 m), battery life is short, Arduino Uno's computational power restricts advanced autonomy, and the platform lacks ruggedization for harsh field conditions. The system can easily be extended for IoT-based remote data logging

VIII. FUTURE SCOPE

Future improvements could include GPS/GSM integration for extended range, AI-based object recognition, autonomous navigation, swarm robotics, robotic arms for manipulation, solar power adoption, rugged hardware design, and upgrading wireless control to RF or cellular networks for enhanced operational reach. AI-based target tracking

IX. CONCLUSION

A practical, integrated military robot prototype using Arduino and IoT technology has been developed and validated. It combines multiple reconnaissance and hazard detection functions within a single, cost-efficient system. Future improvements could focus on extending communication capabilities, incorporating autonomous navigation, and expanding sensor functionality.

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