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Border Surveillance Bot

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Abstract: In modern military operations, robots play a crucial role in carrying out high-risk tasks that are too dangerous for soldiers. Military integrated systems, including video screens, sensors, grippers, and cameras, allowing them to perform various functions effectively. These robots come in different shapes and designs, tailored to specific mission requirements. This system that utilizes a low- power IoT-based wireless sensor network to detect intruders (unauthorized individuals) and enable the robot to take necessary actions autonomously. The Intelligent Unmanned Robot (IUR) enhances national security by reducing human casualties and minimizing manual errors in defence operations. Designed specifically for military applications, this robotic system aims to protect soldiers and safeguard the nation from enemy threats. At border security posts, where tanks, missiles, and firearms pose significant dangers, the proposed robot can assist in defense operations.

Index Terms **– Intelligent Unmanned Robot (IUR), IOT Wireless network, Military robot.**

I. INTRODUCTION

The IoT-based security system aims to enhance border protection and prevent infiltrations, inspired by the Kargil War (1999), which emphasized the need for advanced defense mechanisms. This system integrates infrared (IR) sensors, cameras, GPS tracking, and wireless communication to detect intruders and ensure real-time surveillance. Upon detecting unauthorized movement, IR sensors trigger alarms while cameras capture live footage and transmit it to authorized personnel. Additionally, the system includes poisonous gas and bomb detection to identify potential threats. A unique feature is the use of GPS-enabled bullets, allowing security forces to track an intruder's movement if they attempt to escape. The system also leverages Radio Frequency (RF) wireless communication to transmit data securely, ensuring real-time alerts via mobile devices. By combining IOT technologies, this advanced security mechanism strengthens border surveillance, minimizes risks, and enhances national defense capabilities. This system offers proactive threat detection using infrared sensors and cameras for real- time intruder identification, ensuring continuous surveillance and rapid response. It optimizes border control for constant human patrols while detecting various threats, including intruders and explosives. GPS tracking enhances intruder monitoring, increasing apprehension success. Remote access allows authorized personnel to monitor and control security from anywhere, while AI-powered analysis minimizes false alarms. Drones provide aerial surveillance of hard-to-reach areas, and block chain secures data transmission. The automated response mechanism enables quick actions like activating floodlights or locking gates without human intervention.

II. LITERATURE SURVEY

Multifunctional Robot for Military Applications [1] introduces a biped walking robot using a Parallel Leg Mechanism (PLM) designed for military surveillance. The robot enhances reconnaissance tasks by incorporating digital image processing for real-time obstacle detection. It provides a humanlike movement advantage in controlled environments. However, its functionality is limited to plain surfaces, making it ineffective in rough terrains, and it struggles with efficient movement, reducing real-world applicability.

The Touch Screen Controlled Defense Robot [2] utilizes a touchscreen interface combined with ZigBee communication for remotely operating a military robot. This system benefits from continuous real-time monitoring via a wireless camera, offering an easy-to-use control mechanism. It is cost- effective and supports various robotic applications with low-power ZigBee communication. However, ZigBee's limited range makes it unsuitable for long- distance operations, and network constraints may cause delays in data transmission.

The IoT-Based Surveillance Robot [3] employs Raspberry Pi for real-time monitoring and video recording, providing a low-cost and scalable surveillance solution. It supports image processing, remote monitoring, and external EEPROM for enhanced storage. Despite its advantages, Raspberry Pi has limited memory and consumes more power than conventional PCs. Additionally, the L293D driver chip results in a 1.5V voltage drop, which reduces operational efficiency.

The IoT-Based Wireless Multifunctional Robot for Military Applications [4] integrates Raspberry Pi 3 with various sensors, cameras, grippers, and actuators, using the MQTT protocol for military surveillance. The system enables real-time data transmission and web-based monitoring, making it highly functional for defense applications. However, Raspberry Pi 3's high power consumption and limited memory pose challenges. Furthermore, MQTT is vulnerable to security threats such as SYN attacks, sequence manipulation, and DNS flaws.

The Wireless Multifunctional Robot for Military Applications [5] utilizes 3G-based communication for remote surveillance in border areas. The robot supports both autonomous and manual operation, using multi-sensor capabilities to detect human presence, bombs, harmful gases, and fire. It ensures real-time data access through internet-based communication. However, it relies on the PIC18F452 controller, which uses RISC computation, leading to complex programming. Additionally, the PIC controller has limited memory access, reducing processing efficiency.

The Security Considerations in AI-Robotics [6] provide a comprehensive survey on cybersecurity risks in AI-powered military robotics. The study highlights the importance of encryption, intrusion detection, and authentication protocols for securing robotic systems. Despite these security measures, AI-driven robots remain susceptible to adversarial attacks, data breaches, and communication vulnerabilities, requiring continuous advancements in cybersecurity strategies.

The Hazardous Gas & Mine Detecting Robot [7] is designed for high-risk environments such as coal mines and war zones. It utilizes multiple sensors, including gas, metal, PIR, and IR sensors, to detect hazardous materials and landmines. The robot supports both manual and autonomous navigation while integrating a wireless camera for real-time monitoring. However, its reliance on Bluetooth connectivity limits its operational range, and continuous sensor operation demands high power consumption.

The Unmanned Multi-Functional Robot Using ZigBee [8] explores the use of Intelligent Unmanned Robots (IUR) for military applications, leveraging ZigBee-based wireless sensor networks for real-time surveillance and reconnaissance. The robot is equipped with temperature, moisture, gas, and metal sensors, along with a CMOS camera for monitoring. It provides better efficiency compared to Bluetooth or infrared communication. However, ZigBee's restricted range reduces its effectiveness for large- scale military operations, and the PIC microcontroller requires complex programming, limiting system flexibility.

The IoT-Trained Merciless BSF [9] is a multifunctional military robot designed for border security and surveillance. It autonomously detects and neutralizes intruders using PIR and IR sensors for motion detection and a laser gun for automated threat response. Remote communication is achieved via Bluetooth and GSM, improving operational efficiency. Despite these advantages, the system has limited AI-driven decision-

making capabilities, requiring further enhancements to improve response time and expand its operational range.

The Merciless Border Security System [10] introduces an autonomous robotic defense system integrating IR sensors, laser guns, and detection modules to secure border areas. It automates surveillance, intruder detection, and hazard response while utilizing IoT for reliable communication. The robot is controlled via a mobile application using Bluetooth, allowing for remote monitoring and maneuvering. However, Bluetooth-based control limits the robot's range and overall effectiveness. Further integration of AI could improve its threat assessment and adaptability in complex military scenarios.

III. METHODOLOGY

3.1 Block diagram

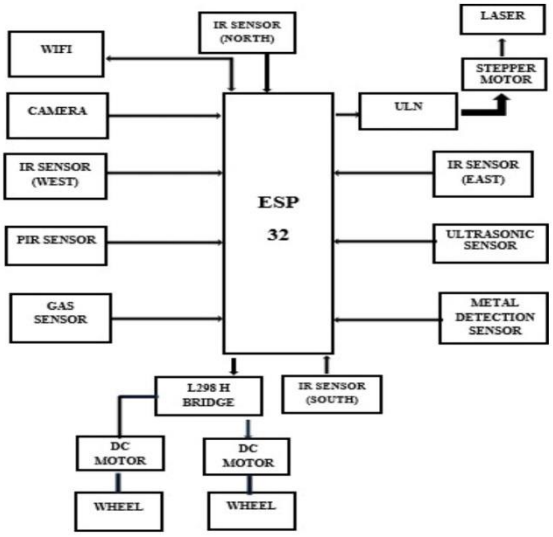

Fig.1 Block diagram of Border surveillance Bot**.**

Figure 1 represents an ESP32 microcontroller, integrating multiple sensors for automation or robotic applications. The ESP32 is the central processing unit, interfacing with various input and output components.

3.2 Objectives

The objectives are as following :

- The system operates continuously 24/7, without the need for breaks, sleep, or vacations, ensuring constant surveillance and protection.
- It detects harmful gases and mines.
- Equipped with camera surveillance, it captures images and sends them to relevant authorities for real-time monitoring.

3.3 Working

The proposed system is a highly advanced autonomous security robot designed to enhance border surveillance and threat response. It is equipped with infrared (IR) sensors to detect intruders, triggering alarms and activating defense mechanisms, including GPS-enabled bullets that track targets in real-time. The system integrates high-resolution cameras, thermal imaging, and night vision to provide continuous monitoring, transmitting live feeds to a control center via Wi-Fi. Motion sensors and facial recognition technology allow for precise intruder detection and classification. For navigation, the robot uses path planning and obstacle avoidance, enabling it to traverse rough terrain efficiently. It operates in both manual and autonomous modes, controlled remotely via a touchscreen interface or mobile application. The inclusion of gas and mine sensors enhances safety by detecting hazardous substances and explosives, sending immediate alerts with GPS

coordinates for rapid response. Powered by a solar- rechargeable battery system, the robot ensures uninterrupted operations, while an energy-efficient standby mode conserves power. Wi-Fi-based communication allows real-time data transfer and remote monitoring, making it a versatile and highly effective security solution. This multifunctional robot is designed for border surveillance, terrorist threat management, bomb detection, and hazardous area patrolling. With its combination of automation, AI- driven threat detection, and smart defense systems, it provides a reliable, cost-effective approach to modern military and border security operations

4 Flow Chart

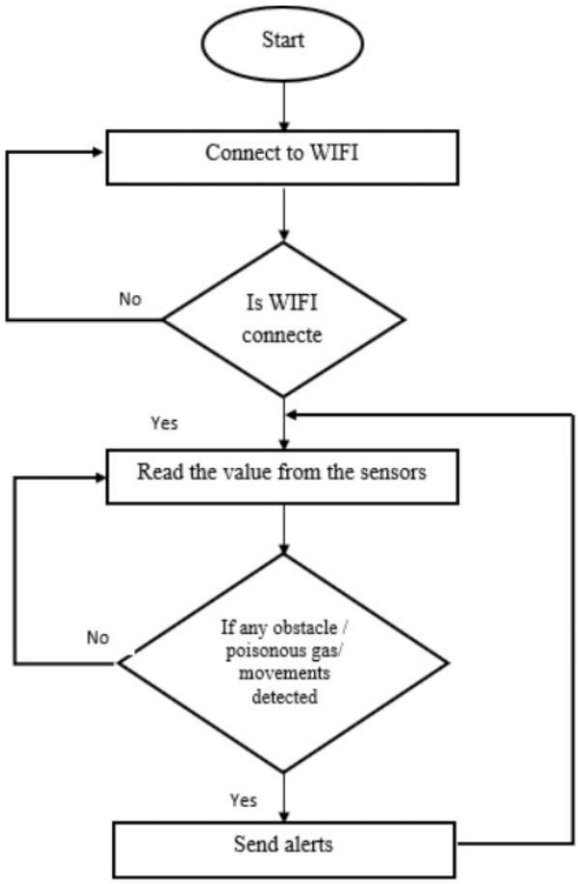

Fig.2 Flow Chart of Border surveillance Bot.

IV. RESULTS AND DISCUSSION

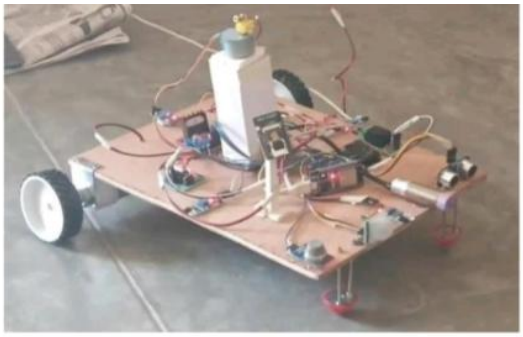

Fig.3 Border Surveillance Bot

The robot detects intruders using IR and PIR sensors, triggering alarms and activating a gun mechanism for security enforcement. It also transmits real-time video to a monitoring system for remote surveillance. By integrating GPS tracking, the system can locate intruders even if they escape after detection. This enhances border security while minimizing risks to soldiers in high- conflict areas.

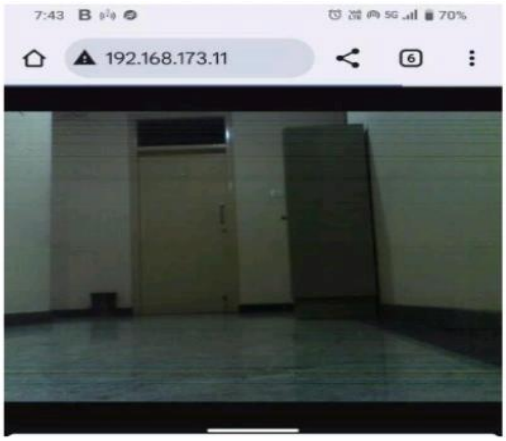

Fig.4 GPS tracking

The Fig.4 shows border surveillance bot operates in manual mode, where it is remotely controlled via a touchscreen or mobile app, and autonomous mode, using GPS-based path planning.

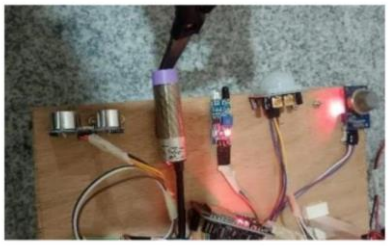

Fig.5a Metal is detected

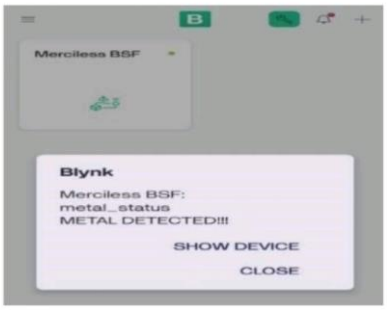

Fig.5b Notification

The Fig 5a and 5b shows that the metal is detected and the notification is sent to the mobile. From the notification we can know that the metal is detected by the Bot.

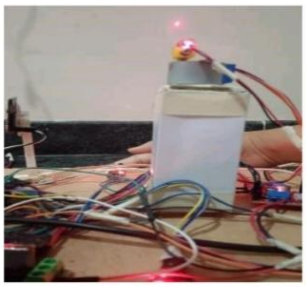

Fig.6 The laser is pointed at the direction of the obstacle

From the Fig 6 we can know that the laser gun points in the direction of the obstacle, when the IR Sensor senses the obstacle in a particular direction, the laser guns points at the obstacle in the direction where the

Fig.7 Surgical gas is detected

obstacle is detected.

The Fig 7 shows that surgical gas is detected. The surgical gas is detected, which is sent as a notification to the mobile.

Fig.8 obstacle is detected

The Fig 8 shows that the obstacle is detected. The ultrasonic sensor senses the obstacle and the notification is

Fig.9 Alive human is detected

sent to the mobile.

The Fig 9 shows that alive human is detected .As soon as the PIR sensor detects the alive human , the notification is sent to the mobile.

V. CONCLUSION

The Border Surveillance Bot provides an automated, intelligent, and cost-effective solution for military surveillance and security. By reducing human casualties, it enhances the efficiency of border protection forces. The combination of intruder detection, real-time alerts, GPS tracking, and obstacle avoidance makes it a robust security tool. While the proposed design appears promising, real-world testing is essential to assess its reliability under combat conditions. Further improvements, such as AI-driven threat analysis, could enhance its effectiveness.

VI. APPLICATIONS

Border Security – Detects intruders, tracks threats, and transmits live video.
Military Reconnaissance – Scouts enemies, detects landmines, and gathers intelligence.
Counter-Terrorism – Patrols, identifies threats, and assists in crises.
Disaster Response – Finds survivors, navigates hazards, and relays data.
Military Surveillance-The multifunctional robot can be deployed in border areas to monitor for intruders and provide real-time video feedback, enhancing security and reducing the risk to soldiers.
Emergency Rescue Operations-The robot can access areas that are dangerous or unreachable for humans, equipped with cameras and sensors to assist in search and rescue missions.
Chemical Leak Detection-The integration of chemical sensors allows the robot to detect harmful gas leaks, providing early warnings to prevent hazardous situations.
Spy Operations-The robot can be used for covert surveillance, gathering intelligence without detection, making it valuable for security agencies.

VII. FUTURE SCOPE

AI can be integrated for advanced threat detection, facial recognition, and autonomous decision-making.
Mobility can be improved with all-terrain capabilities for better performance in extreme environments.
Communication can be enhanced using 5G and satellite networks for faster and long-range data transmission.
Non-lethal defense options like stun guns and tear gas can be added for crowd control and de- escalation.
Swarm robotics can be implemented to deploy multiple synchronized robots for large-area surveillance and defense.

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