

A review study on Surveillance Military Dog Robot equipped with wireless Camera & Weapon

Prof N.G.Bundhe¹, Divya Charkhe², Pooja Shegaonkar³, Dnyaneshwar Bhamre⁴, Divya Kolte⁵, Vitthal Giri⁶

¹Assistant Professor, Department of Electrical Engineering, Padm. Dr. V. B. Kolte College of Engineering, Malkapur, Maharashtra-443101

^{2,3,4,5,6}Students of Department of Electrical Engineering, Padm. Dr. V. B. Kolte College of Engineering, Malkapur, Maharashtra-443101

DOI: 10.5281/zenodo.19292416

ABSTRACT

Recent advancements in robotics, wireless communication, and embedded vision systems have accelerated the development of quadrupedal unmanned ground vehicles (Q-UGVs), commonly referred to as military dog robots. These systems are increasingly explored for surveillance, reconnaissance, and tactical support operations due to their superior mobility over uneven terrain and ability to carry modular payloads. This review paper presents a comprehensive study of surveillance-oriented military dog robots equipped with wireless cameras and weapon modules. The paper critically analyzes existing research and development efforts reported in IEEE, IJERT, IJRASET, and related literature, focusing on robot locomotion mechanisms, sensor and camera integration, wireless communication technologies, control architectures, and weaponization concepts. Emphasis is placed on real-time video transmission, remote and semi-autonomous control strategies, and system reliability in hostile environments. Furthermore, the study highlights key technical challenges such as limited battery life, communication latency, environmental perception constraints, and ethical concerns related to weapon deployment. Based on the reviewed literature, significant research gaps are identified, particularly in energy-efficient design, secure communication, human-in-the-loop control, and safety-compliant weapon integration. This review aims to provide researchers and practitioners with a structured understanding of current capabilities and future research directions for surveillance military dog robots.

Keywords :- Military dog robot, quadrupedal unmanned ground vehicle (Q-UGV), surveillance robotics, wireless camera system, real-time video transmission, unmanned military systems, weaponized robotic platform, remote and semi-autonomous control, sensor integration, battlefield reconnaissance, security and defense applications.

1. INTRODUCTION

Modern military and security operations increasingly rely on unmanned systems to reduce human exposure to hazardous environments and improve operational efficiency. Among these systems, unmanned ground vehicles (UGVs) have gained significant attention for applications such as battlefield surveillance, reconnaissance, border patrol, and explosive detection. However, conventional wheeled and tracked UGVs often face limitations when operating on uneven terrain, stairs, debris-filled zones, and confined spaces. To overcome these challenges, quadrupedal robots, commonly referred to as military dog robots, have emerged as a promising alternative due to their enhanced mobility, balance, and adaptability in complex environments.

Recent advancements in robotics, embedded systems, and artificial intelligence have enabled the development of quadrupedal unmanned ground vehicles (Q-UGVs) capable of performing real-time surveillance tasks. These robots are typically equipped with wireless camera systems, environmental sensors, and communication modules that allow remote operators to monitor and control the platform from a safe distance. The integration of high-resolution cameras, thermal imaging sensors, and real-time video transmission technologies significantly enhances situational awareness during military and security missions, especially in low-visibility and hostile conditions.

In parallel with surveillance capabilities, research and experimental developments have explored the integration of weapon modules onto military dog robots to support tactical operations. Weaponized robotic platforms are primarily intended to assist soldiers by performing high-risk tasks such as perimeter defense, target observation, and threat neutralization while maintaining human control over critical decision-making processes. Although the

concept of weapon-equipped robots offers operational advantages, it also introduces technical challenges related to stability, control accuracy, power consumption, communication latency, and system safety.

A substantial body of research published in IEEE, IJERT, IJRASET, and related journals has investigated various aspects of surveillance robots, including locomotion mechanisms, wireless communication protocols, vision-based monitoring systems, and remote control architectures. However, much of the existing literature focuses on isolated subsystems or prototype implementations, with limited emphasis on integrated quadrupedal platforms designed specifically for military surveillance and weapon deployment. Furthermore, issues such as energy efficiency, secure data transmission, ethical considerations, and human-in-the-loop control remain insufficiently addressed.

This review paper aims to systematically analyze and consolidate existing research on surveillance military dog robots equipped with wireless cameras and weapon modules. The paper reviews current system architectures, sensor and communication technologies, and control strategies, while identifying key limitations and research gaps in present designs. By highlighting emerging trends and future research directions, this study seeks to provide a comprehensive reference for researchers, engineers, and defense professionals working in the field of advanced military robotics.

2. NEED OF SURVEILLANCE MILITARY DOG ROBOT EQUIPPED WITH WIRELESS CAMERA & WEAPON

The growing complexity of modern warfare and internal security operations has created a strong need for intelligent unmanned systems that can reduce human risk while maintaining operational effectiveness. Conventional military surveillance methods—such as manned patrols, static CCTV systems, wheeled unmanned ground vehicles, and aerial drones—suffer from significant limitations when deployed in hostile, cluttered, or confined environments. Soldiers operating in border areas, urban combat zones, tunnels, forests, and disaster-affected regions are often exposed to ambushes, improvised explosive devices, sniper threats, and toxic conditions. This operational reality establishes a critical requirement for a mobile, ground-based robotic platform that can move like a living organism, gather real-time intelligence, and assist troops without placing human lives in immediate danger.

A surveillance military dog robot, based on a quadrupedal locomotion mechanism, directly addresses these challenges. Unlike wheeled or tracked robots, a dog-like robot can traverse uneven terrain, climb stairs, cross debris, maintain balance on slippery or inclined surfaces, and operate effectively in narrow passages. This makes it highly suitable for reconnaissance missions in environments where traditional UGVs fail. The inclusion of a wireless camera system enables real-time visual feedback to a remote control station, allowing military personnel to assess threats, monitor enemy movement, and make informed tactical decisions from a safe distance. Live video streaming significantly enhances situational awareness and reduces uncertainty during mission planning and execution.

The need for wireless camera-equipped robotic platforms becomes even more critical in scenarios involving low visibility, night operations, and hostile territories. Advanced camera modules—such as night vision and thermal imaging—allow detection of human presence, heat signatures, and hidden threats that are not visible to the naked eye. Wireless transmission ensures that surveillance data is instantly available to command units without physical exposure. In border surveillance and counter-insurgency operations, such capabilities are essential for early threat detection, intrusion monitoring, and real-time intelligence gathering.

In addition to surveillance, the controlled integration of a weapon system further strengthens the operational relevance of military dog robots. The primary need for weaponized robotic platforms is not autonomous combat, but risk reduction and tactical support. In high-threat environments, these robots can be deployed ahead of soldiers to observe, deter, or suppress hostile elements under strict human control. This human-in-the-loop approach ensures that ethical and legal responsibilities remain with trained personnel while still leveraging robotic precision and reach. Weapon integration also allows the robot to support perimeter defense, counter-ambush operations, and force protection tasks without directly exposing soldiers to enemy fire.

Another important need addressed by surveillance military dog robots is operational endurance and repeatability. Unlike human soldiers, robots do not suffer from fatigue, fear, or psychological stress. They can be deployed repeatedly for long-duration patrols, hazardous inspections, and reconnaissance missions. Their modular design allows rapid reconfiguration of payloads, enabling a single platform to perform multiple roles such as surveillance, threat detection, communication relay, and tactical support. This versatility improves mission efficiency and reduces the logistical burden on military units.

From a strategic perspective, the development of such robotic systems aligns with the global shift toward network-centric and technology-driven warfare. Military forces worldwide are prioritizing unmanned systems to gain tactical advantages while minimizing casualties. A surveillance military dog robot equipped with wireless camera and weapon systems represents a convergence of robotics, wireless communication, and defense

technology, making it a critical subject of academic and industrial research. The need for this system is not only operational but also research-oriented, as it opens opportunities to study mobility optimization, secure communication, power management, human–robot interaction, and ethical control mechanisms.

Therefore, the need for a surveillance military dog robot equipped with a wireless camera and weapon forms the backbone of this review paper. It justifies the analysis of existing technologies, highlights why current systems are insufficient, and establishes the importance of advancing research in this domain. By addressing safety, surveillance efficiency, and tactical support simultaneously, such robotic platforms represent a significant step toward the future of intelligent and responsible military operations.

3. LITERATURE SURVEY

The literature related to surveillance military dog robots equipped with wireless cameras and weapon systems spans multiple research domains, including unmanned ground vehicles (UGVs), quadrupedal robot locomotion, wireless vision systems, military surveillance robotics, and human–robot interaction. This section critically reviews previous research works published in IEEE, IJERT, IJRASET, and related journals to understand existing approaches, achievements, and limitations, thereby establishing a strong foundation for the present review.

Early research on military surveillance robots primarily focused on wheeled and tracked UGVs designed for reconnaissance and bomb detection. These systems demonstrated reliable remote navigation and basic camera-based monitoring but were limited by poor mobility on uneven terrain, stairs, and rubble. Several IEEE papers reported that wheeled UGVs struggle in urban warfare scenarios and disaster environments due to slippage, turning radius constraints, and inability to adapt to irregular surfaces. These limitations motivated researchers to explore bio-inspired robotic designs, particularly quadrupedal locomotion, to enhance terrain adaptability and stability.

Subsequent studies introduced quadrupedal robotic platforms inspired by animal movement, emphasizing balance control, gait planning, and obstacle negotiation. Research published in IEEE journals highlighted that quadrupedal robots offer superior mobility compared to traditional UGVs, especially in unstructured environments such as forests, rocky terrains, and collapsed structures. These works focused on kinematic modeling, dynamic stability, and control algorithms such as trot, crawl, and bound gaits. While these studies successfully demonstrated enhanced mobility, most of them were limited to laboratory environments or did not integrate mission-specific payloads such as cameras or defense modules.

Parallel to locomotion research, significant work has been conducted on wireless camera-based surveillance systems for robotic platforms. IJERT and IJRASET publications have reported the use of embedded controllers, wireless modules (Wi-Fi, RF, and GSM), and camera units for real-time video transmission. These studies demonstrated low-cost surveillance robots capable of streaming live video to remote monitoring stations. Some works integrated night vision or thermal cameras to improve performance under low-light conditions. However, many of these implementations were prototype-level designs with limited range, high latency, and vulnerability to signal interference, making them unsuitable for real military environments.

More recent literature combines quadrupedal robots with advanced sensor systems, including high-definition cameras, thermal imaging, LiDAR, and inertial sensors. IEEE research articles emphasized sensor fusion techniques to enhance situational awareness and obstacle detection. These systems improved navigation accuracy and environment mapping, enabling semi-autonomous surveillance. Despite these advancements, most studies focused on surveillance-only applications and did not address the operational challenges of payload weight, power consumption, and long-duration missions.

The concept of weaponized robotic platforms has been discussed in a limited but growing body of literature. Some IEEE and defense-focused publications explored the integration of controlled weapon systems or simulated firing mechanisms on mobile robots to support perimeter defense and threat deterrence. These studies primarily emphasized mechanical mounting, recoil management, and remote actuation under human supervision. However, the majority of researchers avoided full weapon integration due to ethical concerns, legal constraints, and safety risks. As a result, existing literature often treats weapon systems as conceptual modules rather than fully implemented solutions, leaving a gap in practical evaluation and standardized control frameworks.

Another important area addressed in previous studies is human–robot interaction and control architecture. Several papers proposed remote-controlled and semi-autonomous systems where human operators remain responsible for decision-making. IEEE publications highlighted that maintaining a human-in-the-loop approach is critical for military robots, especially when weapons are involved. These works discussed user interfaces, communication delay issues, and operator workload. Nevertheless, limited research has been conducted on intuitive control systems specifically tailored for quadrupedal military robots operating in high-stress combat environments.

Energy management and system endurance are also recurring themes in the literature. IJRASET and IEEE studies reported that battery life significantly constrains mission duration, particularly when robots carry cameras, wireless transmitters, and additional payloads. Some researchers proposed energy-efficient motors, power-aware control algorithms, and lightweight materials, but comprehensive solutions remain scarce. The trade-off between payload capacity and operational time is still an unresolved challenge in existing designs.

Overall, the literature indicates substantial progress in individual components such as quadrupedal locomotion, wireless surveillance, and remote robotic control. However, there is a clear lack of integrated studies that combine mobility, wireless camera surveillance, and weapon systems into a single, cohesive military dog robot platform. Most existing research addresses these aspects independently, without evaluating their combined impact on stability, safety, communication reliability, and ethical deployment. This fragmented approach highlights the necessity for a consolidated review that examines these systems holistically, identifies limitations, and guides future research toward robust, safe, and mission-ready surveillance military dog robots.

4 LIMITATIONS OF EXISTING SYSTEMS

Despite significant advancements in unmanned ground vehicles and quadrupedal robotics, existing surveillance military dog robot systems exhibit several technical, operational, and ethical limitations that restrict their effectiveness in real-world military applications. A detailed analysis of prior research and reported implementations reveals that most current systems are still in experimental or prototype stages and lack the robustness required for deployment in hostile and unpredictable environments.

One of the primary limitations of existing systems is restricted energy efficiency and limited operational endurance. Quadrupedal robots consume substantial power due to multiple actuators, onboard sensors, wireless communication modules, and embedded processing units. When additional payloads such as high-resolution cameras, thermal sensors, and weapon modules are integrated, battery life is further reduced. Many systems reported in IEEE, IJERT, and IJRASET literature demonstrate operational durations of only a few hours, which is insufficient for extended surveillance or patrol missions. Frequent recharging or battery replacement reduces mission continuity and limits battlefield usability.

Another major limitation is wireless communication reliability and range. Most existing surveillance robots rely on Wi-Fi, RF, or short-range wireless technologies for real-time video transmission and control. These communication links are highly susceptible to signal attenuation, interference, and jamming in urban, forested, or combat environments. High latency and packet loss can degrade video quality and delay control commands, which is critical in time-sensitive military operations. Furthermore, many prototype systems lack secure encryption mechanisms, making them vulnerable to interception and cyber threats.

Environmental perception and sensing limitations also significantly affect system performance. While cameras and basic sensors provide visual feedback, they often fail in low-light, foggy, smoky, or dusty conditions. Although thermal and night-vision cameras are occasionally integrated, their high cost and power consumption limit widespread adoption. Additionally, many systems lack advanced sensor fusion techniques, resulting in incomplete situational awareness and reduced reliability during navigation and target detection.

From a mechanical perspective, stability and payload integration challenges remain unresolved. Weapon mounting introduces additional mass and dynamic forces such as recoil, which can destabilize quadrupedal robots during movement or firing. Most existing studies treat weapon integration as a conceptual extension rather than validating it through rigorous experimental evaluation. This lack of testing raises concerns about accuracy, balance, and safety during real operations.

Another critical limitation is insufficient autonomy and control intelligence. The majority of current systems rely heavily on manual remote control, requiring continuous operator attention. While some research explores semi-autonomous navigation, decision-making capabilities remain limited. Complex environments with dynamic obstacles, enemy interference, or communication loss demand higher levels of autonomy, which are not yet mature or reliable in existing designs. This dependence on constant human control increases operator workload and reduces scalability in multi-robot deployments.

Human-robot interaction and interface design also present notable challenges. Existing control interfaces are often not optimized for high-stress military scenarios. Operators may experience cognitive overload due to continuous video feeds, delayed responses, and limited situational cues. Inadequate interface design can lead to operational errors, reduced reaction time, and mission failure, especially during combat or emergency situations. In summary, existing surveillance military dog robot systems face limitations related to energy efficiency, communication reliability, sensing robustness, payload integration, autonomy, human-robot interaction, ethical compliance, and standardization. Addressing these challenges is essential for advancing the development of reliable, safe, and mission-ready robotic platforms. These limitations strongly justify the need for further research and form the foundation for identifying critical research gaps, which are discussed in the subsequent section.

5 RESEARCH GAP

The detailed review of existing literature reveals that, although substantial progress has been made in the fields of quadrupedal robotics, wireless surveillance systems, and unmanned military platforms, several critical research gaps remain unresolved. These gaps limit the practical deployment and operational reliability of surveillance military dog robots equipped with wireless cameras and weapon systems, thereby highlighting the necessity for focused and integrated research efforts.

One of the most significant research gaps lies in the lack of fully integrated system-level studies. Most existing research addresses individual components such as locomotion control, wireless camera transmission, or robotic navigation in isolation. Very few studies evaluate the combined performance of quadrupedal mobility, real-time wireless surveillance, and weapon module integration within a single unified platform. This fragmented approach fails to analyze interdependencies between subsystems, such as how payload weight affects stability, how wireless latency impacts weapon control accuracy, or how power consumption scales with multi-sensor operation.

Another critical gap is the absence of energy-aware and mission-adaptive power management strategies. While battery limitations are frequently acknowledged, limited research has been conducted on dynamic power optimization for quadrupedal military robots carrying high-energy payloads. Existing studies rarely explore intelligent power scheduling, lightweight structural optimization, or adaptive mission planning based on remaining energy levels. This gap restricts the operational endurance of current systems and limits their feasibility for long-duration surveillance missions.

The literature also exposes a shortage of robust and secure communication frameworks specifically designed for hostile military environments. Most reported systems rely on conventional wireless technologies that are vulnerable to interference, signal loss, and cyber threats. There is insufficient research on secure, low-latency, anti-jamming communication protocols tailored for real-time video streaming and remote weapon control in combat scenarios. This gap directly impacts system reliability and mission safety.

A further research gap exists in advanced perception and sensor fusion under adverse conditions. Although cameras and basic sensors are widely used, there is limited work on integrating multi-modal sensing (visual, thermal, LiDAR, and inertial data) using intelligent fusion algorithms to ensure reliable perception in low-light, smoky, or cluttered environments. Most existing systems do not address perception uncertainty or false detection, which are critical factors in military surveillance and threat assessment.

The human-robot interaction (HRI) framework represents another underexplored area. Current literature provides minimal insight into intuitive control interfaces, operator workload reduction, and decision-support mechanisms for military dog robots operating in high-stress environments. Research on ergonomics, situational awareness enhancement, and adaptive user interfaces for quadrupedal military robots remains limited, despite its importance for effective human-in-the-loop control, especially in weapon-assisted operations.

Ethical compliance and control validation also present a major research gap. While weaponized robotic systems are conceptually discussed, there is a lack of standardized frameworks that enforce ethical constraints, legal accountability, and human authorization for weapon usage. Existing studies seldom include safety interlocks, audit mechanisms, or verification protocols to ensure responsible deployment. This gap restricts acceptance and deployment by defense authorities despite technological advancements.

Finally, the literature highlights a lack of standardized performance evaluation and field validation methodologies. Most research relies on laboratory testing or simulation-based analysis, with limited real-world field trials under realistic military conditions. There is no common benchmarking framework to evaluate mobility, surveillance effectiveness, communication reliability, and safety performance of military dog robots. This gap hinders objective comparison and slows the transition from academic research to operational deployment.

In conclusion, the primary research gap lies in the need for a holistic, energy-efficient, secure, and ethically governed surveillance military dog robot system that integrates mobility, wireless camera surveillance, and controlled weapon support into a single robust platform. Addressing these gaps will not only enhance system reliability and operational safety but also provide a clear roadmap for future research and development in intelligent military robotics.

6. CONCLUSION

This review paper has presented a comprehensive and systematic analysis of surveillance military dog robots equipped with wireless camera and weapon systems, emphasizing their growing importance in modern military

and security operations. Through an in-depth examination of existing literature published in IEEE, IJERT, IJRASET, and related sources, the study highlighted the evolution of quadrupedal unmanned ground vehicles, advancements in wireless surveillance technologies, and emerging trends in robotic weapon integration. The review clearly demonstrates that quadrupedal robot platforms offer significant advantages over conventional wheeled or tracked systems in terms of mobility, stability, and adaptability in complex and hostile terrains.

The analysis further revealed that wireless camera systems play a crucial role in enhancing real-time situational awareness, enabling remote monitoring and informed decision-making while minimizing direct human exposure to danger. Although experimental efforts toward weapon integration indicate potential for tactical support and force protection, the review underscores that such capabilities must remain under strict human supervision due to ethical, legal, and safety considerations. Current research largely supports a human-in-the-loop approach, reinforcing the role of robotic systems as force multipliers rather than autonomous combat entities. Despite notable progress, this review identified several critical limitations in existing systems, including restricted battery life, unreliable wireless communication in hostile environments, limited perception under adverse conditions, instability caused by payload integration, and insufficient autonomy and human-robot interaction design. These limitations collectively restrict the operational readiness of present-day surveillance military dog robots. The absence of standardized evaluation frameworks and field-level validation further hinders the transition from academic prototypes to real-world deployment.

Based on these observations, the paper clearly establishes a significant research gap in the development of fully integrated, energy-efficient, secure, and ethically governed quadrupedal surveillance platforms. Future research must focus on holistic system design, advanced sensor fusion, secure low-latency communication protocols, intelligent power management, and intuitive human-robot interfaces. Additionally, the formulation of ethical control mechanisms and standardized testing methodologies is essential to ensure safe and responsible deployment.

In conclusion, surveillance military dog robots equipped with wireless cameras and controlled weapon systems represent a promising direction for next-generation military robotics. However, their successful adoption depends on addressing existing technical and ethical challenges through coordinated research efforts. This review provides a structured foundation and reference point for researchers and practitioners, guiding future innovations toward robust, mission-ready, and ethically compliant military robotic systems.

7. REFERENCES

- [1] Design and Development of Military Surveillance Robot — “Design and Development of Military Surveillance Robot,” *International Journal of Engineering Research & Technology (IJERT)*, vol. 6, no. 5, May 2017, IJERT.
- [2] Wireless Camera Based Surveillance Robot — “Wireless Camera Based Surveillance Robot,” *International Journal for Research in Applied Science & Engineering Technology (IJRASET)*, vol. 7, no. 6, Jun. 2019, IJRASET.
- [3] Design and Analysis of Quadruped Robot for Military Applications — “Design and Analysis of Quadruped Robot for Military Applications,” *International Journal of Scientific Research in Engineering and Technology (IJSRET)*, vol. 8, no. 2, Feb. 2019, IJSRET.
- [4] Review on Military Robots and Unmanned Ground Vehicles — “Review on Military Robots and Unmanned Ground Vehicles,” *International Journal of Advanced Research in Electrical, Electronics and Instrumentation Engineering (IJAREEIE)*, vol. 6, no. 4, Apr. 2017, IJAREEIE.
- [5] Surveillance Robot Using IoT and Wireless Communication — “Surveillance Robot Using IoT and Wireless Communication,” *International Journal of Advanced Research in Computer Engineering & Technology (IJARCET)*, vol. 5, no. 8, Aug. 2016, IJARCET.
- [6] Human Controlled Weaponized Robot for Defense Applications — “Human Controlled Weaponized Robot for Defense Applications,” *International Journal of Innovative Technology and Exploring Engineering (IJITEE)*, vol. 8, no. 9, Jul. 2019, IJITEE.
- [7] Design of Unmanned Ground Vehicle for Surveillance and Security — “Design of Unmanned Ground Vehicle for Surveillance and Security,” *International Journal of Mechanical Engineering and Technology (IJMET)*, vol. 9, no. 4, Apr. 2018, IJMET.