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Wolf Pack – Modular Mission Payloads for Quadruped Unmanned Ground Vehicles

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ABSTRACT

United States adversaries are advancing unmanned systems (UxS) at an exponential rate. New advancements in lightweight intelligence, surveillance, reconnaissance (ISR) targeting sensors, size, weight, and power (SWAP) computational payloads, machine learning (ML) and artificial intelligence (AI), have generated an advanced threat to U.S. forces. The recent conflict in Ukraine illustrates the usage of lethal, weaponized UxS at scale in both conventional and irregular warfare and demonstrates the need for robotic systems capable of autonomous precision targeting and kinetic defeat. [1]

The Wolf Pack project aims at developing modular weapons payloads (MWP) for quadruped unmanned ground vehicles (Q-UGV). The MWP system would integrate precision targeting sensors, networked lethality software, narrow AI/ML precision trackers, and advanced fire control with weapon systems such as rifles (M4), anti-armor (AT-4) and tube launched systems (40mm loitering munition). The MWP system would run on embedded, real-time, at the edge, computing modules where SWAP is very challenging. The Wolf Pack would be integrated across distributed lethal networks to enable collaborative and coordinated lethal effects.

1. INTRODUCTION

In an era characterized by rapid technological advancements and evolving security threats, the United States faces unprecedented challenges in maintaining its national security posture. The emergence of new adversaries, unconventional warfare tactics, and the proliferation of advanced military technologies underscore the need for continuous innovation and adaptation

within the U.S. military [1]. The integration of weaponized quadrupeds equipped with dynamic multi-mission payloads represents a transformative leap forward in military technology, offering novel solutions to address the complexities of modern warfare. Weaponized quadrupeds have received increasing attention from defense agencies and technologists due to their remarkable

Proceedings of the 2024 Ground Vehicle Systems Engineering and Technology Symposium (GVSETS) versatility and adaptability. These robotic platforms, powered by advanced sensors, artificial intelligence, and advanced technologies, exhibit unparalleled mobility across diverse terrains, including urban environments, rugged landscapes, and hazardous zones. Their ability to traverse difficult terrain, navigate obstacles, and operate autonomously makes them valuable assets for a wide range of military missions, spanning reconnaissance, surveillance, combat support, and disaster response. As the geopolitical landscape evolves and new threats emerge, the United States must leverage innovative technologies to maintain its military superiority and safeguard its national interests. The integration of weaponized quadrupeds into the U.S. military arsenal represents a strategic imperative, offering a force multiplier effect that enhances operational capabilities and effectiveness across various domains. Moreover, the ongoing conflict in regions such as Ukraine serves as a stark reminder of the importance of adaptable and agile military platforms capable of operating in complex and dynamic environments. This paper will explore the strategic significance of weaponized quadrupeds in enhancing United States national security. It will examine their operational advantages, technological innovations, and ethical considerations. It will investigate the role of artificial intelligence (AI) and machine learning (ML) in augmenting the capabilities of weaponized quadrupeds, further strengthening U.S. military readiness and effectiveness. It will address the challenges and obstacles facing the integration of

Weaponized quadrupeds into military operations, emphasizing the need for concerted efforts to overcome these hurdles and to maximize the potential of these advanced robotic systems. It will then diverge to the advantages of the Wolf Pack project, which considers all the items discussed in this paper, while providing the capability of integrating modular weapon payloads onto quadrupeds.

2. National Security

Weaponized quadrupeds provide the United States with strategic advantages in terms of national security, significantly enhancing its defense capabilities and readiness to address diverse threats. These advanced robotic platforms offer increased force projection capabilities, allowing the U.S. military to extend its reach into remote or hostile environments where deploying conventional forces may be challenging. Equipped with advanced sensors, surveillance systems, and communication technologies, weaponized quadrupeds enhance situational awareness for military commanders and decision-makers. They gather intelligence, monitor enemy activities, and relay critical information in real-time, facilitating timely and informed decision-making processes. Moreover, these robotic platforms improve operational efficiency by offering a cost-effective solution for a wide range of military missions, including reconnaissance, surveillance, target acquisition, and logistical support. The flexibility and adaptability of weaponized quadrupeds make them valuable assets for responding to dynamic and asymmetric threats, such as

Proceedings of the 2024 Ground Vehicle Systems Engineering and Technology Symposium (GVSETS) insurgencies, terrorist attacks, or natural disasters. In terms of global security implications, weaponized quadrupeds strengthen deterrence capabilities and enhance national defense by providing advanced military technology to deter potential adversaries and defend against emerging threats. However, their proliferation among other nations may contribute to strategic competition and arms races, potentially destabilizing regional security dynamics and increasing the risk of conflict escalation [1].

3. Considerations

Weaponized quadrupeds offer a multitude of operational advantages, technological innovations, ethical considerations, and implications for global security. Operationally, they excel in maneuverability, possessing superior mobility over diverse terrains like urban environments, rugged landscapes, and hazardous zones, enabling access to locations inaccessible to traditional tactical vehicles. Equipped with advanced sensors and surveillance systems, they provide real-time intelligence, enhancing decision-making processes and mission effectiveness. They serve as force multipliers by augmenting the capabilities of human personnel and traditional military assets, enabling more efficient resource utilization, and reducing personnel risk. By deploying weaponized quadrupeds in high-risk environments, the United States can reduce the exposure of human personnel to danger and mitigate casualties, thereby enhancing force protection and minimizing operational risks. Technologically, weaponized

quadrupeds feature advanced sensor systems such as cameras, LIDAR, and infrared sensors, allowing them to perceive and analyze their surroundings effectively. They utilize autonomous navigation algorithms to traverse terrain autonomously, reducing the need for human intervention and enhancing operational efficiency. They can be equipped with a variety of mission-specific payloads, including weapons systems, communication devices, and medical supplies, enhancing their versatility and adaptability in different scenarios.

Integration of AI algorithms enables these platforms to process large amounts of data, make real-time decisions, and adapt to dynamic environments, enhancing their autonomy and effectiveness. Ethically, the use of weaponized quadrupeds raises concerns regarding their potential impact on civilian populations and infrastructure, necessitating careful consideration of collateral damage and civilian casualties. Debates surround the level of autonomy granted to these platforms and the implications for accountability in case of unintended consequences or misuse. Compliance with international humanitarian law, including principles of proportionality, distinction, and necessity, is crucial to mitigate the risk of violations and ensure ethical conduct in warfare. Nevertheless, they can also be deployed for humanitarian assistance and disaster response missions, contributing to global security by providing rapid and effective support in times of crisis.

4. Machine Learning and Artificial Intelligence

Machine learning (ML) and artificial intelligence (AI) play a pivotal role in augmenting the capabilities of weaponized quadrupeds and further strengthening U.S. military readiness and effectiveness. These advanced technologies empower quadrupeds with enhanced autonomy, adaptability, and intelligence, enabling them to perform a wide range of complex tasks more efficiently and effectively. ML and AI algorithms enable weaponized quadrupeds to analyze vast amounts of sensor data in real-time, allowing them to make informed decisions autonomously. By processing data from various sources such as cameras, LIDAR, and infrared sensors, quadrupeds can accurately perceive their surroundings, identify potential threats, and respond proactively to changing situations on the battlefield. This capability significantly enhances situational awareness and responsiveness, enabling faster and more effective decision-making by military commanders. ML algorithms enable weaponized quadrupeds to learn from their experiences and improve their performance over time. By continuously analyzing data and adapting their behavior based on feedback, quadrupeds can optimize their operational efficiency, adapt to new environments, and anticipate future challenges more effectively. This capability is particularly valuable in dynamic and unpredictable scenarios, where traditional rule-based systems may struggle to cope with changing conditions. AI integration enables weaponized quadrupeds to collaborate with other autonomous systems

Proceedings of the 2024 Ground Vehicle Systems Engineering and Technology Symposium (GVSETS) and human operators seamlessly, enhancing overall mission effectiveness and coordination. Through advanced communication and coordination algorithms, quadrupeds can share information, coordinate movements, and execute collaborative tasks with other assets in the battlefield, such as drones, ground vehicles, and infantry units. This interoperability and synergy between different elements of the military force improve overall operational effectiveness and enable more complex and coordinated military operations. ML and AI enable weaponized quadrupeds to adapt to diverse mission requirements and operational environments more effectively. By analyzing historical data and patterns, quadrupeds can potentially anticipate future missions and optimize their configurations and strategies accordingly. Whether conducting reconnaissance, surveillance, combat support, or logistical tasks, quadrupeds can dynamically adjust their behavior and mission parameters to maximize their contribution to the overall mission objectives. Overall, the integration of ML and AI technologies enhances the capabilities of weaponized quadrupeds and strengthens U.S. military readiness and effectiveness by improving situational awareness, decision-making, adaptability, collaboration, and mission performance. By leveraging these advanced technologies, the U.S. military can enhance its operational capabilities, maintain a competitive edge over potential adversaries, and effectively address emerging threats and challenges in today's complex and dynamic security environment. [3]

5. Challenges

The integration of weaponized quadrupeds into military operations encounters various challenges and obstacles that require concerted efforts to overcome and maximize the potential of these advanced robotic systems. Technological complexity presents a significant hurdle, demanding substantial investment in research, development, and testing to ensure reliability and performance under diverse operational conditions. Interoperability issues arise in integrating quadrupeds with existing military systems, necessitating compatible standards and interfaces for seamless communication and collaboration with other assets. Ethical considerations surrounding the use of weaponized quadrupeds in warfare, including civilian casualties and adherence to international humanitarian law, require careful deliberation to ensure responsible and ethical conduct on the battlefield. Moreover, the development of new training programs, tactics, techniques, and procedures is essential to effectively integrate weaponized quadrupeds into military operations. This involves training personnel to operate and maintain quadrupeds and integrating them into existing military units and workflows. Public perception and acceptance of weaponized quadrupeds also play a crucial role and must be addressed to increase support and trust. Concerns about autonomy, accountability, and ethical implications necessitate transparent communication and engagement with the public to foster understanding and acceptance [4].

Power and weight limitations pose challenges that impact endurance, mobility, and payload capacity. Overcoming these constraints requires developing lightweight yet robust power sources and optimizing energy efficiency. Collaborative efforts among military organizations, defense contractors, policymakers, and researchers are essential to address these challenges effectively [5].

6. Wolf Pack

The Wolf Pack project aims to integrate modular mission payloads onto quadrupeds, which would enhance their versatility, adaptability, and effectiveness in military operations. One key advantage is flexibility, as modular payloads allow quadrupeds to adapt to a wide range of mission requirements without extensive modifications or specialized equipment. They can easily swap out or reconfigure payloads based on specific operational needs, enabling tasks such as reconnaissance, surveillance, logistics support, and combat operations. Modular payloads offer scalability, allowing quadrupeds to adjust their capabilities according to mission complexity and operational objectives. By selecting and integrating appropriate payloads, quadrupeds can enhance their functionality and performance to meet evolving mission requirements while ensuring optimal resource utilization. Customization is another significant advantage, as modular payloads enable quadrupeds to be tailored to specific mission profiles and operational environments.[6] Military units can configure quadrupeds with mission-specific

Proceedings of the 2024 Ground Vehicle Systems Engineering and Technology Symposium (GVSETS) sensors, communication systems, weapons, or other equipment to address unique challenges encountered in different scenarios. Modularity is facilitated through compatible interfaces and standardized connectors, allowing for seamless integration and communication between quadrupeds and other military assets. This modularity enhances collaboration and coordination among diverse platforms, facilitating more effective joint operations. Modular payloads support upgradability, enabling quadrupeds to integrate new sensors, equipment, and capabilities as they become available. This ensures that quadrupeds remain relevant and effective in dynamic and evolving operational environments, maintaining their operational superiority over time. By utilizing modular payloads, military units can optimize resource allocation and reduce logistical burdens associated with deploying specialized equipment for different missions. This resource efficiency enables more agile and cost-effective operations, enhancing overall mission readiness and sustainability. The integration of modular mission payloads onto quadrupeds enhances their versatility, adaptability, and effectiveness in military operations. With the advantages such as flexibility, scalability, customization, modularity, upgradability, and resource efficiency, modular payloads empower quadrupeds to

perform a wide range of missions with enhanced capabilities and operational agility.

7. REFERENCES

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