

Comprehensive Overview of Key Technologies in U.S. Army Unmanned Combat Vehicles

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Abstract: With the continuous changes in the world situation, especially the rise of technologies and battlefield applications related to unmanned combat, countries around the world have gradually begun to research unmanned combat related technologies. As the world's most powerful ground combat force, the US Army has been seeking innovative ways to enhance its combat capabilities and keeping up with the latest forms of military development, comprehensively strengthening research on unmanned combat related technologies. Unmanned combat vehicles have been designated as key components in future war scenarios. This article adopts methods such as literature search, achievement comparison, and example demonstration. Through systematic analysis, the aim is to conduct in-depth research and testing on key technologies related to unmanned combat vehicles in the United States Army, especially in autonomous navigation, artificial intelligence, sensor technology, and communication systems. Through research, it attempts to identify how the United States Army improves its combat efficiency by strengthening research on key technologies related to unmanned combat vehicles, and use this as a reference for the development of unmanned combat vehicle technology in our army.

Keywords: U.S. Army; Unmanned Warfare; Combat Vehicles; Key Technologies

1. Introduction

Amidst the ongoing evolution of modern warfare, the role of unmanned combat vehicles on the battlefield has grown increasingly paramount. Ranging from battlefield reconnaissance to direct engagement, the development of unmanned combat vehicles

holds immense potential [1]. The U.S. Army has recognized this significance, deeming research into the key technologies of unmanned combat vehicles essential for enhancing the combat capabilities and battlefield efficiency of the U.S. Army. Consequently, efforts to intensify research on the critical technologies of unmanned combat vehicles have been initiated.

Currently, the U.S. Army's research on critical technologies for unmanned combat vehicles is primarily divided into two key areas. Firstly, there is a focus on enhancing the autonomy and intelligence levels of these vehicles. Through advancements in artificial intelligence and autonomous navigation technologies, unmanned combat vehicles are being empowered to undertake complex missions and make independent tactical decisions without human intervention. This development not only reduces reliance on human resources but also enhances the vehicles' maneuverability and adaptability on the battlefield [2]. Secondly, significant efforts are being directed towards improving the perceptual and identification capabilities of unmanned combat vehicles to better navigate the ever-evolving battlefield landscape. By integrating state-of-the-art sensor technologies and image recognition algorithms, these vehicles can accurately detect and identify enemy targets, allowing for timely and effective responses. Such advancements are poised to strengthen the U.S. Army's offensive capabilities and operational efficiency, thereby increasing soldiers' chances of survival and overall mission success. Taken together, the U.S. Army's research on critical technologies for unmanned combat vehicles has reached a significant level of achievement. This progress is expected to provide vital support in upholding national security and realizing military objectives in the complexities of

modern warfare.

This article conducts in-depth research on key technologies such as automatic navigation, artificial intelligence, sensor technology, and communication systems of unmanned combat vehicles in the US Army, attempting to systematically analyze how the US Army can improve combat efficiency by strengthening research on key technologies of unmanned combat vehicles, and provide reference for the development of unmanned combat vehicle technology in our army.

2. Sensing Technologies

2.1 Radar Technology

Radar technology stands as a commonly employed sensing technique for Unmanned Combat Vehicles (UCVs), enabling real-time perception of surrounding environments and objects, facilitating autonomous decision-making and navigation [3]. Within the U.S. Army's critical technological research on unmanned combat vehicles, radar technology assumes a pivotal role. Apart from furnishing real-time perceptual capabilities, radar technology excels in long-range target detection and tracking, maintaining remarkable accuracy and reliability even in adverse weather conditions and intricate terrains. In recent years, the U.S. Army's research and development investments have led to continual enhancements and refinements in radar technology. These improvements have notably expanded detection ranges and target resolution, better aligning with the requirements of unmanned combat vehicles. Statistics indicate that improved radar technology has elevated target detection accuracy for unmanned combat vehicles by 10% and boosted target localization precision by 15% in complex urban settings. These figures underscore the significant contributions of radar technology to enhancing the performance of unmanned combat vehicles, underscoring the significance of further research and refinement in radar technology. The progression of this technology profoundly strengthens the U.S. Army's UCV units, enhancing their advantages and combat capabilities on the battlefield.

2.2 Cameras and Sensors

Cameras and sensors constitute vital

components of the U.S. Army's unmanned combat vehicles' perception and identification technologies. Equipped with high-resolution cameras and a variety of sensors, unmanned combat vehicles can capture real-time images and perceptual data of their surrounding environment. These cameras and sensors are adept at identifying and tracking targets, including enemy vehicles and personnel, thereby furnishing the military with real-time intelligence and operational information [4]. According to statistical data, unmanned combat vehicles outfitted with high-performance cameras and sensors are capable of more accurately perceiving and identifying targets, thereby enhancing operational precision and efficiency. Hence, camera and sensor technologies play a crucial role in the U.S. Army's critical technological research on unmanned combat vehicles.

2.3 Laser Technology

Laser technology plays a pivotal role in enhancing the tactical capabilities of unmanned combat vehicles within the U.S. Army. Leveraging laser technology, laser sensors can precisely measure the distance and speed of targets, as well as acquire information regarding the shape and texture of targets. This enables unmanned combat vehicles to swiftly and accurately assess the level of threat posed by targets and respond accordingly, facilitating precise target identification and engagement. Consequently, unmanned combat vehicles exhibit enhanced accuracy and efficiency in target engagement, ensuring a more precise and effective strike against targets [5]. The application of laser technology not only elevates the combat prowess of unmanned combat vehicles but also minimizes instances of collateral damage and harm to civilians, thereby enhancing operational effectiveness. The U.S. Army has conducted extensive research and experimentation in the realm of laser technology to advance the technological development of unmanned combat vehicles continually. Within laser technology research, the U.S. Army also prioritizes enhancing the power and efficiency of lasers. By augmenting the power of lasers, unmanned combat vehicles can possess enhanced striking capabilities, effectively neutralizing enemy targets. Furthermore, increasing the efficiency of lasers extends the operational duration of

unmanned combat vehicles, reducing the need for frequent energy source replacements, thereby heightening operational efficiency and endurance.

Beyond laser technology, unmanned combat vehicles employ various other sensor technologies to enhance their combat capabilities. For instance, infrared sensor technology facilitates target detection during nighttime or adverse weather conditions, granting unmanned combat vehicles all-weather operational capabilities. Radar and sonar technologies enable long-range target detection and tracking, assisting unmanned combat vehicles in effectively detecting and engaging enemy targets.

In conclusion, sensor technologies, particularly the application of laser technology, play a crucial role in augmenting the combat capabilities of U.S. Army unmanned combat vehicles. Through precise target identification and engagement capabilities, unmanned combat vehicles can exert greater power on the battlefield, enhance operational effectiveness, and safeguard the lives of soldiers. Furthermore, with the continuous evolution and innovation of technology, the sensor technologies of unmanned combat vehicles will continue to advance, providing a more diverse and robust array of choices for their battlefield applications.

3. Navigation and Control Technologies

3.1 Global Positioning System (GPS)

The Global Positioning System (GPS) stands as a crucial technology for the navigation and control of unmanned combat vehicles, enabling precise localization of these vehicles and furnishing accurate navigational data. The U.S. Army extensively integrates GPS technology into unmanned combat vehicle development, empowering them to navigate with precision in intricate battlefield environments and execute targeted offensive and defensive maneuvers. Moreover, GPS aids military strategists in conducting strategic analyses and decision-making by amassing extensive location data. Statistics indicate that U.S. Army unmanned combat vehicles leveraging GPS technology have achieved heightened success rates and accuracy in operations, significantly enhancing operational efficiency. Therefore, GPS technology stands

as an indispensable component within the core technological research of U.S. Army unmanned combat vehicles.

3.2 Advanced Autonomous Navigation Technology

Within the realm of U.S. Army unmanned combat vehicles, advanced autonomous navigation technology stands as a pivotal cornerstone. To ensure the precise execution of missions and the prevention of collisions, this technology demands a sophisticated fusion of high-precision positioning and intricately designed mapping capabilities [6]. High-precision positioning, facilitated through sensors like the Global Positioning System (GPS) and cutting-edge laser radar systems, facilitates the accurate determination of the vehicle's exact position while enabling comprehensive environmental awareness. The construction of detailed maps necessitates the utilization of advanced tools such as laser scanners and high-resolution cameras, which meticulously model the vehicle's surroundings to provide the crucial foundation of reliable mapping data.

Moreover, the efficacy of autonomous navigation hinges on the seamless integration of path planning algorithms and obstacle avoidance mechanisms. These components collectively empower combat vehicles to navigate securely through complex terrains. Path planning algorithms dynamically formulate optimal routes tailored to mission objectives and environmental exigencies, thereby enhancing operational efficiency to its zenith. Simultaneously, obstacle avoidance capabilities, driven by sensor inputs and sophisticated target recognition algorithms, actively detect and circumvent obstacles in real-time, facilitating agile adjustments to the vehicle's trajectory to evade potential collisions effectively.

Furthermore, autonomous navigation technology necessitates competent decision-making and control capabilities to empower combat vehicles to adapt to environmental dynamics and mission exigencies. This entails the adept translation of decisions into concrete control directives in real-time, facilitated by robust computational prowess and intelligent algorithms. Such integration enables precise control over mechanical executions, facilitating the

seamless autonomy of combat vehicles in their navigation.

In essence, autonomous navigation technology stands as a cornerstone within the U.S. Army's arsenal of unmanned combat vehicles. Through dedicated research and practical application in areas like high-precision positioning, map construction, path planning, obstacle avoidance, decision-making, and control, combat vehicles can fulfill tasks with precision, efficiency, and safety. These advancements provide robust support to the operational capabilities of the U.S. Army, bolstering their combat readiness [7].

4. Communication and Data Transmission Technologies

4.1 Satellite Communication Technology

The paramount significance of satellite communication technology in the realm of U.S. Army unmanned combat vehicles cannot be overstated. Satellite communication technology offers expansive coverage and steadfast connectivity, enabling unmanned combat vehicles to engage in remote control and command operations over considerable distances. For instance, when deployed in remote regions for missions, satellite communication technology ensures stable signal transmission, facilitating real-time data transfer and operational commands with the central command center. Furthermore, satellite communication technology boasts robust anti-jamming capabilities, effectively countering enemy interference and signal obfuscation. Consequently, the application of satellite communication technology in unmanned combat vehicles has emerged as a pivotal method for the U.S. Army to enhance operational efficiency and realize remote warfare capabilities [8]. Moreover, satellite communication technology provides high-bandwidth and low-latency data transmission capabilities, crucial for supporting unmanned combat vehicles in high-speed real-time data transfer and remote monitoring. This capability is indispensable for the seamless operation of unmanned combat vehicles, which require prompt reception and transmission of voluminous data encompassing environmental insights, target identifications, operational directives, and more. The high-speed data transmission

capacity of satellite communication technology ensures swift information dissemination on the battlefield and facilitates real-time decision-making, enhancing the responsiveness and operational efficacy of unmanned combat vehicles.

Additionally, satellite communication technology offers global coverage, enabling unmanned combat vehicles to achieve remote control and command capabilities worldwide. Whether engaged in domestic operations or international military endeavors, satellite communication technology ensures seamless connectivity, guaranteeing unimpeded communication between unmanned combat vehicles and command centers. This global connectivity enhances the operational capabilities of unmanned combat vehicles and enables swift responses and deployments during emergencies, thereby fostering flexibility and rapidity in battlefield command and strategic dispatch.

In conclusion, satellite communication technology plays a pivotal role in U.S. Army unmanned combat vehicles. Its attributes of extensive coverage, steadfast connectivity, high-speed data transmission, and global remote control empower unmanned combat vehicles to execute tasks with enhanced efficiency and precision, elevating operational efficacy and strategic deployment capabilities. Moving forward, with the continuous evolution and innovation of satellite communication technology, the critical technologies within unmanned combat vehicles will continue to advance and progress, providing robust support for military operations.

4.2 Wireless Network Communication Technology

Wireless network communication technology plays a pivotal role in the essential research efforts concerning U.S. Army unmanned combat vehicles. This advanced technology facilitates real-time communication and seamless data transmission between these vehicles and central command hubs, thereby significantly enhancing operational efficiency and ensuring harmonious cooperation among the fleet. Moreover, the use of wireless network communication technology extends the reach of data transmission, ensuring more stable connections. This allows unmanned

combat vehicles to gather crucial environmental intelligence and execute missions with unparalleled precision. Reports indicate a remarkable 30% increase in command and control efficiency within U.S. military unmanned combat vehicles employing wireless network communication technology. Furthermore, there has been a noteworthy rise in the success rates of mission executions, underscoring the indispensable nature of this technology in enhancing operational outcomes [9]. Beyond its operational advantages, wireless network communication technology boasts resilient anti-jamming capabilities and exceptional stealth characteristics, safeguarding communication channels against potential disruptions and unauthorized access. These qualities are paramount for ensuring the security of U.S. Army unmanned combat vehicles. Rigorous real-world tests have validated the stability and reliability of signal transmissions in vehicles utilizing this technology, reinforcing its practicality and effectiveness in military operations.

Furthermore, with the relentless advancement of technology, wireless network communication technology continues to undergo innovation and refinement. For instance, the integration of techniques such as multipath transmission and adaptive bitrate adjustment enhances channel utilization and transmission speeds significantly. Additionally, research on high-speed wireless communication technology based on millimeter-wave technology holds promise for further elevating the communication capabilities and efficiency of unmanned combat vehicles [10].

In conclusion, wireless network communication technology plays a paramount role in the critical technological research of U.S. Army unmanned combat vehicles. It facilitates real-time communication and data transmission between these vehicles and central command centers, thereby enhancing command and control efficiency. Furthermore, it ensures extended-range and stable data transmission, thereby boosting the success rates of mission executions for unmanned combat vehicles. Additionally, the technology's robust anti-jamming capabilities and exceptional stealth properties guarantee the security of unmanned combat vehicles. As technology continues to evolve and improve,

wireless network communication technology will further enhance the communication capabilities and efficiency of unmanned combat vehicles.

5. Conclusions

The research findings indicate that the development of key technologies for U.S. Army unmanned combat vehicles is crucial in enhancing operational capabilities and military power. Leveraging the advantages of unmanned combat vehicles, such as mitigating risks to soldiers and enhancing operational efficiency, the U.S. military can gain a significant edge on the battlefield. The integration of perception and navigation technologies enables unmanned combat vehicles to execute missions with heightened precision, thus creating tactical advantages for the military. Furthermore, the utilization of unmanned combat vehicles not only spurs advancements and innovations in military technology but also drives technological progress within the military domain. From an economic perspective, unmanned combat vehicles offer lower operational costs while enhancing combat effectiveness and conserving human resources. Therefore, the achievements of the U.S. Army in the research of key technologies for unmanned combat vehicles hold significant importance in realizing national security and military strategic objectives.

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