REVIEW ON APPLICATIONS OF MILITARY ROBOTS

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ABSTRACT:

Military robots (or unmanned combat platforms, UCP) are the main components of unmanned combat systems. In general, military robots are capable of achieving autonomous control and remote control, are recyclable or disposable and can carry deadly and lethal loads. On the battlefield, military robots can perform a variety of combat missions, such as battlefield approach reconnaissance and surveillance, accurate guidance and damage assessment, sneak attack and targeted clearance, combat material transportation, communication relay, and so on. With the help of military robots, the flexibility and continuity of combat operations can be effectively improved. In addition to battlefield, military robots are also capable of replacing people to complete various tasks in a high-risk environment. In a word, military robots will play an increasingly important role in the future. This assignment will introduce the development, technologies, trends, and applications of military robots in recent years.

KEYWORDS: Military robots, Unmanned combat platform, Autonomy, Reliability.

I. CLASSIFICATION

According to the areas of utilization, military robots can be divided into the following categories: unmanned aerial systems (UAS), unmanned ground vehicles (UGV), unmanned surface vehicles (USV), unmanned marine systems (UMS), and unattended ground sensor (UGS) [1]. As an essential branch of military robots, UGV has received extensive attention all over the world in recent years. Military unmanned vehicles appeared in the 1980s, while the ground unmanned combat systems were formed in the 1990s, which have made considerable progress. The development of military unmanned vehicles is roughly divided into three stages: remote control stage, semi-autonomous stage, and autonomous unmanned vehicle stage. According to the tasks performed, unmanned vehicles can be divided into reconnaissance type, detonation type, logistics support type, and assault type, etc. In the US Army's "Joint Robot Project", the unmanned vehicles are categorized according to the weights [1] (see Table. 1).

II. DEVELOPMENT AND APPLICATIONS

In recent years, unmanned systems have been vigorously developed among various countries in the world and been widely applied to the military field. Unmanned vehicle, however, is one of the most concerned components for unmanned systems in the world.

Table. 1 Classification of Unmanned Vehicles

Category	Weight
Micro	8 lbs (3.6 kg)
Miniature	8-30 lbs (3.6-13.6 kg)
Small - Light	31-400 lbs (14.0-181.4 kg)
Small - Medium	401-2500 lbs (182.0-1134.0 kg)
Small - Heavy	2501-20000 lbs (1134.0-9072.0 kg)
Medium	20001-30000 lbs (9072.0-13608.0 kg)
Large	>30000 lbs (13608.0 kg)

II-A. DEVELOPMENT

In the "Unmanned Ground System Roadmap" which was released by the United States Robotics System Joint Planning Office in 2011, the autonomous navigation technology, communication technology, power technology, vision technology, system architecture technology, human-machine interface technology, manipulation technology, complex terrain maneuvering technology, and load technology are identified as key technologies essential for the development of unmanned ground systems [2]. After years of development, military robots have made significant progress in critical technologies such as communication, strike, and autonomy, while paying more attention to the reliability and practicality of equipment.

As for the development strategy of UCP, the United States focuses on the development of military unmanned combat systems. Canada 's research and development areas include autonomous systems, control systems, data communication systems, robot platforms, artificial intelligence, and human-computer interaction technologies. Germany focuses on the development of critical technologies for ground-based unmanned systems, including perception technology, intelligent control, and autonomous robot platforms; in recent years, Germany has begun to develop small portable robots. The critical areas of research and development in Australia are platform-related technologies and weapon technologies, man-unmanned collaborative systems, control theory, and control systems. The focus of French R & D is on system collaboration technology, weapon technology, autonomy, night vision technology, and so on.

With the continuous improvement of intelligent control, some countries pay more attention to the development of semi-autonomous unmanned vehicles. The advantage lies in the organic integration of human intelligence and machine intelligence to maximize the combat effectiveness of the platform. At the same time, the research of the single ground unmanned combat platform began to shift to the research of the multi-platform cooperative combat system, that is, the research of ground unmanned combat platform group. In the future, the development trend of the ground-based unmanned combat system is to meet the requirements

(a) (b) (c) (d)

Figure. 1 Standard Robot Test Ground

of complex environments, breaking through new environmental perception, autonomous planning, and multi-platform collaboration theories and technologies.

II-B. BATTLEFIELD APPLICATIONS

The U.S. Department of Defense issued the "Unmanned System Comprehensive Roadmap 2013-2038" in 2013. This roadmap emphasizes the application capabilities of unmanned systems in war. It proposed that there are three main reasons for the long-term development of unmanned systems:

- The urgent need for unmanned systems in war.
- In the case of continuous tightening of the investment budget of the entire defense system, the development of unmanned systems will meet the best cost-effective ratio.
- The changing national security situation brings some unique challenges, and special environments that are difficult or impossible to access require unmanned systems.

At the same time, it is pointed out that although unmanned vehicles have proved their value in combat operations throughout the Middle East and Central Asia, the current technology must be expanded and included in the core of national defense construction. In the future, unmanned vehicles will be required to work in more complex environments [3].

The National Institute of Standards (NIST) and the Southwest Research Institute have jointly established a standard robot test ground (see Figure. 1), which is specifically used to perform various performance tests on ground unmanned combat systems [4]. It can test the maneuverability, communication and endurance capabilities, and autonomous capabilities of the ground unmanned combat system on various terrains. Various typical scene facilities are built to test the actual combat performance of the ground unmanned combat system.

At present, many countries have incorporated ground unmanned combat equipment into future weapons development plans, and already have unmanned combat platforms used in actual combat. During the Iraq War, the U.S. military had more than 8,000 ground unmanned systems for different combat missions; as of September 2010, the U.S. military ground unmanned systems were used for more than 125,000 combat missions, including suspicious object identification and road clearance, cleanup of temporary explosives, and so on. As for the

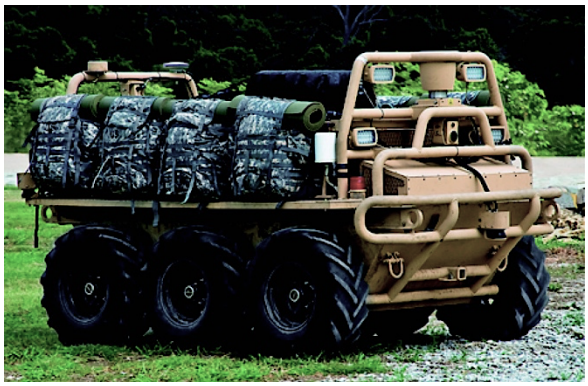


Figure. 2 SMSS in Afghanistan

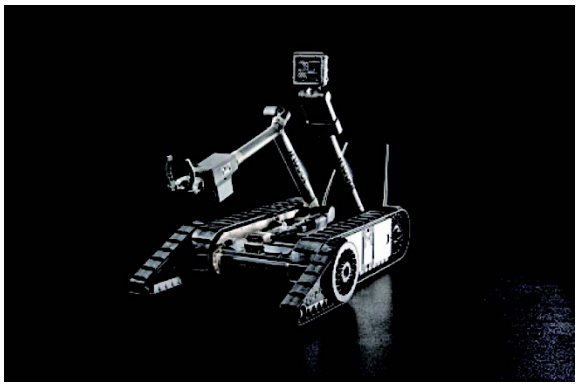
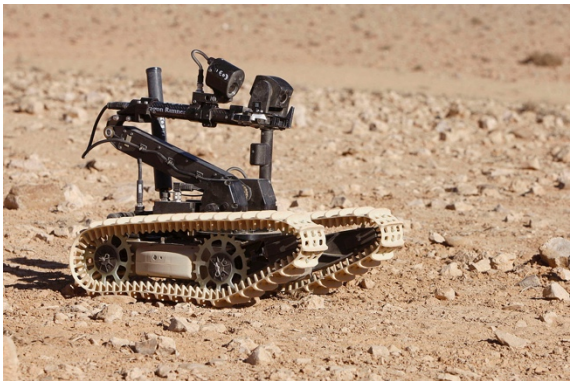


Figure. 3 PackBot



(a)

(b)

Figure. 4 Dragon Runner

mine clearance mission, the Army, Navy, and Marine Corps Explosive Ordnance Disposal Task Force has processed more than 11,000 explosives using ground unmanned systems [3]. The application of unmanned systems has begun to develop from a single-type driving mechanism mobile platform to a special-type and compound driving mechanism mobile platform, with more diverse functions, continuous improvement of autonomy, and increased adaptability to complex environments. The squad mission support system (SMSS) (see Figure. 2) under study by the U.S. military already has many autonomous capabilities such as voice control, autonomous control, and path planning and has gradually become serialized. The vehicle has entered the battlefield in Afghanistan for actual combat testing [5].

The "PackBot" (see Figure. 3) is one of the most successful unmanned light weapon combat platform prototypes supported by DARPA, and its tactical use-value is fully reflected in the wars in Afghanistan and Iraq. "PackBot" is a portable system that can cope with various adverse environments. It can quickly replace the battery, quickly disassemble the adjustment track, the adjustment track has an automatic adjustment function. Due to the aluminum alloy shell, "PackBot" is very durable. The prototype of the sports platform can withstand the

Figure. 5 MAARS

Figure. 6 Guardian

impact of the ground at the height of 3 m from the concrete floor and can be dropped from the second-floor intact many times. More than 3,500 "PackBots" have been put into application in military and public safety organizations of various countries around the world, and are used in the fields of reconnaissance, monitoring, detection, detonation, and so on.

The "Dragon Runner" (see Figure. 4) is QinetiQ's first fully modular ground robot that can be operated by one person with a standard backpack. No special equipment is required, and the moving and static objects in the area can be photographed quickly. "Dragon Runner" can be used to perform multiple missions, and can perform reconnaissance missions in buildings, sewers, and courtyards. A large number of "Dragon Runners" have been put into applications, such as performing reconnaissance and detonation missions on the battlefield in Afghanistan.

Modular advanced armed robot system, or MAARS, is one of the most advanced members of the unmanned ground reconnaissance vehicle family (see Figure. 5). Compared with the early SWORDS system, its platform is larger and more powerful. It can carry M240B/G machine guns or four 40 mm M203 grenade launchers. The robot has been evaluated on the battlefield in Iraq.

The Israel "Guardian" (see Figure. 6) carries cameras, night vision, and sensors, as well as machine guns and other weapons. It can patrol along the isolation zone according to a pre-set route, and can also cross the city alone. The unmanned vehicle began serving in the Israel Defense Forces in early 2008. It has the capabilities of situational awareness, autonomous maneuvering, and independent decision-making. It can perform combat missions such as reconnaissance patrols, fire strikes, and combat support.

The "BigDog" (see Figure. 7) is a dynamic balancing quadruped robot developed by Boston Dynamics, Foster-Miller Corporation, Jet Propulsion Laboratory, and Harford University 's Condefield Research Station in 2005. The four legs of the "BigDog" imitate the design of the animal's limbs entirely, and a special shock absorber is installed inside. A computer installed inside the "BigDog" robot can adjust the traveling posture according to the changes in the environment. "BigDog" can travel along a pre-set simple route on its own, or it can be controlled remotely. It is called "the most advanced robot in the world that adapts to rough terrain."

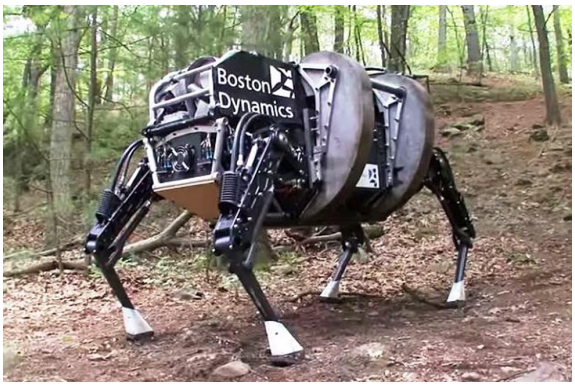


Figure. 7 BigDog

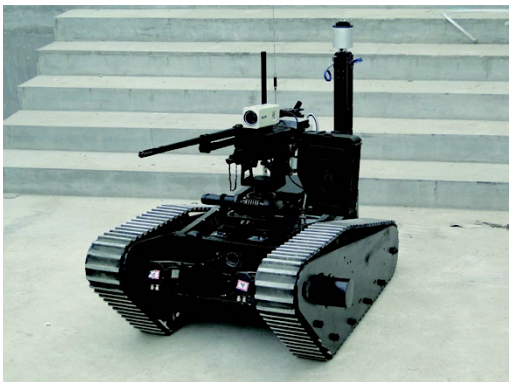


Figure. 8 Intelligent Combat Robot

III. Military Robots in China

Based on China's current demographic and social structure, the demand for unmanned systems is not very urgent when compared with countries such as the United States. But in the long run, mankind can do most of the work now, and may not be able to do all the work in the future, especially in the dangerous military field.

After years of implementation of the plan, China has made breakthroughs in military robot technology and shortened the gap with developed countries. With the support of the General Armament Department of the Chinese People's Liberation Army, the National Defense Science and Technology Industry Bureau and the National 863 Program, some Chinese universities and research institutes have conducted research on light robotic systems such as mobile robots and intelligent vehicles since the 1980s. China develops relatively mature robot products, which are mainly used in the fields of industry, fire protection, and detonation. China 's higher-level scientific research institutes focus their development on autonomous control of unmanned platforms. Research in this area is mainly at the stage of retrofit testing of existing vehicles, and there is no mature product application yet.

At present, the technology of remote-controlled unmanned platforms has been basically mature, and many prototypes have been developed and put into use in small quantities; semi-autonomous unmanned platforms aim at the development and verification of critical technologies. In respect of this, only a few critical technical studies have been carried out, and no prototypes have been developed yet. During the Eleventh Five-Year Plan period, China carried out research on the "Light Weapons Intelligent Combat Platform Technology" project, which realized the remote control operation and strike functions of the light weapons intelligent combat platform (see Figure. 8), and had certain terrain traversal capabilities, but the speed is relatively slow.

IV. Comparison

After years of development, the ground unmanned combat platform has formed an equipment architecture and troop deployment plan, and gradually developed toward serialization,

generalization, and autonomy. At the same time, people have paid more attention to the reliability and practicability of the equipment. China's ground unmanned combat platform has also developed to a certain extent in recent years. However, due to the lack of unified planning and deployment and supporting construction, it is still in a state of disordered development. The technology is scattered and lacks communication. There is a certain distance from the standardization and serialization, which can be reflected in the following aspects:

- The U.S., Canada, Germany, and France have apparent advantages in autonomous control technology. They have conducted in-depth research on autonomous motion control technology, target detection, and recognition technology, human-machine cooperation, and intelligent control technology of ground unmanned combat platforms. For example, the Crusher unmanned vehicle, which is being developed and tested in the United States, has research goals of completely autonomous movement and highly intelligent control. Some ground unmanned combat platforms in China have applied autonomous technologies such as autonomous obstacle avoidance and path planning, but generally speaking, the degree of autonomy is not high, and most of them are remote control or semi-autonomous products. At present, most of the research on autonomous control technology is still in the theoretical research and preliminary test stage.
- Many countries have researched and designed a series of ground unmanned combat platforms with different maneuverability. According to the movement mode, they are mainly divided into crawler, wheel, leg, compound, and so on. In terms of core components, structural design, and maneuverability, many of which have been tested in actual combat or equipped with troops. China has also developed different types of military unmanned vehicles, but the whole is in the stage of imitation and learning, and the maneuverability is poor. There are few products that truly meet the requirements of the actual battlefield environment. Due to the excessive dependence of core components on imports, the degree of localization is low, which results in the domestic platform hardware technology being constrained by people and the high cost, which limits the promotion and application.
- Some developed countries have developed a series of standards for the design, production, and inspection of military robot platforms. After continuous testing and actual examination, the reliability of their production systems has a significant advantage over China. During the test and application process, China's ground-based military robots exposed many deficiencies in mechanism reliability, electrical reliability, software reliability, anti-jamming capability, and environmental adaptability.

V. CONCLUSION

In this assignment, the recent development, technologies, trends, and applications of military robots have been reviewed in detail. At present, unmanned vehicles have been put into use in large quantities, and there are more than a dozen types of equipment, involving large, medium, and small. Most unmanned vehicles are used for reconnaissance tasks, and a few are used for attack and logistics support tasks. From the perspective of the development of unmanned vehicles, the early implementation of anti-detonation missions has been

continuously expanded in recent years, expanding to reconnaissance, armed attacks, and logistics support. It also shows a trend toward multi-function development [6].

In terms of technology, the existing unmanned combat system weapon load is borrowed from the current standard weapons, and it is not suitable for unmanned combat systems in terms of weapon loading or firing action completion methods. This borrowing mode significantly affects. In view of the overall integration and safety of unmanned combat systems, the development of special weapons should be gradually put on the agenda.

With the improvement of the informatization, and artificial intelligence, the battlefield environment becomes more and more complex, and the demand for unmanned systems will become more urgent. An unmanned combat system that can supplement or replace the existing combat system will be one of the inevitable trends for future development.

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