ISBN 978-1-84626-xxx-x
Proceedings of 2011 International Conference on Optimization of the Robots and Manipulators (OPTIROB 2011)
Sinaia, Romania, 26-28 Mai, 2011, pp. xxx-xxx

Military R&D Involvement in Developing Unmanned Systems for Defense and Security

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Abstract. The paper aims to present the actual status of military robots development by Romanian military Research and Development in the context of today's warfare and military operations.

Keywords: battlefield, robots, human live saving, risk, R&D.

1. Introduction

The history of military robots can be traced back to the times of World War II. During the time of World War II and the Cold War, these robots were in the form of German Goliath tracked and Soviet teletanks. It is also believed that military robots history can be dated back to the 19th century, precisely in 1898. The history begins with the invention of radio controlled boat intended for military use by Nicola Tesla.

For the last few decades, robots are becoming very popular and common in military organizations. There are many military robots used by military organizations for taking many risky jobs that cannot be done by human.

Military robots find major applications in surveillance, reconnaissance, location and destruction of mines and IEDs, as well as for offense or attack. The latter class of vehicles is equipped with weapons, which at the present time are fired by remote human controllers.

2. Military Robots

2.1. International overview

The age when unmanned robots will replace soldiers on the battlefield is not far off. Research is under way in the Army to develop a future combat system by 2025 where soldiers engage in combat alongside military robots. Around the world combat robots that mimic a wide range of organisms including humans, dogs, scorpions, centipedes, lizards, fish and even grasshoppers are being developed. China, France, Japan, Switzerland, the U.K. and the U.S. are developing robots that resemble fish which can function as unmanned submarines. The Massachusetts Institute of Technology already tested the "Robotuna," while research is under way for China's "Dongle," France's "Jessiko," Japan's "Robotic Koi" and Switzerland's "Boxybot." Research is also under way for snake-like amphibious robots.

The United States leads the world in the development of military robots. "Packbot," which has already been tested in Afghanistan and Iraq, is equipped with a shotgun capable of sustained, long-distance fire, while a mounted camera relays images in real time. The U.S. military's favorite robots are the "Talon," designed to defuse explosive devices, the "Panther," which removes mines and the "Predator" drone used for unmanned aerial surveillance and bombing missions. Robots are especially useful on dangerous missions such as scouting enemy territory or removing explosives.

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The Korean military deployed the "Aegis" robot for troops sent to Iraq. It is capable of guard duty and lethal attacks on enemy targets. The military plans to deploy Aegis robots along the demilitarized zone.

3. Ground Robots

The Army makes use of two major types of autonomous and semi-autonomous ground vehicles: large vehicles, such as tanks, trucks and HUMVEEs and small vehicles, which may be carried by a soldier in a backpack (such as the PackBot). The PackBot is equipped with cameras and communication equipment and may include manipulators (arms); it is designed to find and detonate IEDs, thus saving lives (both civilian and military), as well as to perform reconnaissance. Its small size enables it to enter buildings, report on possible occupants, and trigger booby traps. Armed robot vehicles are, for example, the Talon SWORDS (Special Weapons Observation Reconnaissance Detection System) made by Foster-Miller, which can be equipped with machine guns, grenade launchers, or anti-tank rocket launchers as well as cameras and other sensors. While vehicles such as SWORDS are able to autonomously navigate toward specific targets through its global positioning system (GPS), at present the firing of any on-board weapons is done by a soldier located a safe distance away.

Among the larger vehicles, the US Army has developed a 5.5 ton, six-wheel unmanned vehicle known as the Crusher, capable of carrying 2,000 lbs. at about 30 mph and capable of withstanding a mine explosion; it is equipped with one or more guns.

One special category of ground robot is the carrier type that aims to release the soldier's burden of his equipment (fig. 1.d). In this sense also there are developments on different type of exoskeletons that should increase soldier strength and make him able to carry a bigger load (fig. 1.e).

Fig. 1: Ground Robots

Aerial Robots

The Army's, Air Forces, and Navy's have developed a variety of robotic aircraft known as unmanned flying vehicles (UAVs). Like the ground vehicles, these robots have dual applications: they can be used for reconnaissance without endangering human pilots, and they can carry missiles and other weapons. The services use hundreds of unarmed UAVs, some as small as a model airplane, to locate and identify enemy targets. An important function for unarmed UAVs is to serve as aerial targets for piloted aircraft. Some reconnaissance UAVs, such as the Shadow, are launched by a catapult and can stay aloft all day. The best

known armed UAVs are the semi-autonomous Predator Unmanned Combat Air Vehicles (UCAV) built by General Atomics which can be equipped with Hellfire missiles. Both the Predator and the larger Reaper hunter-killer aircraft are used extensively in Afghanistan. They can navigate autonomously toward targets specified by GPS coordinates, but a remote operator located in Nevada (or in Germany) makes the final decision to release the missiles.

The military services are also developing very small aircraft, sometimes called Micro Air Vehicles (MAV) capable of carrying a camera and sending images back to their base. Other AUVs include a ducted fan vehicle being used in Iraq, and vehicles with flapping wings.

Other flying robots either deployed or in development, including helicopters, tiny robots the size of a bumblebee, and solar-powered craft capable of remaining aloft for days or weeks at a time.

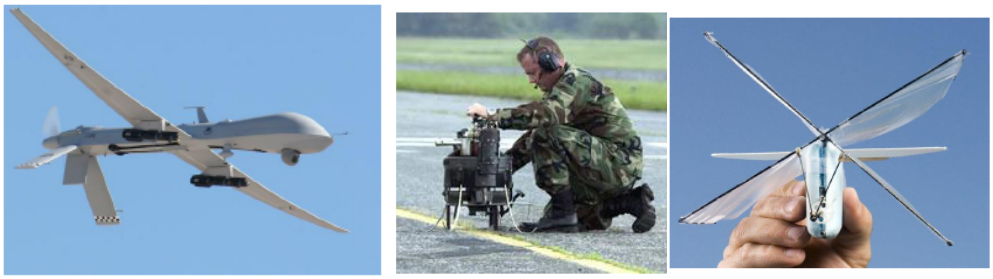

Fig. 2: Aerial Robots.

Marine Robots

The Navy has also interest in the field of unmanned vehicles. During the time their developments include surface ships as well as Unmanned Underwater Vehicles (UUVs). Their applications include surveillance, reconnaissance, anti-submarine warfare, mine detection and clearing, oceanography, communications, and others. It should be noted that contemporary torpedoes may be classified as UUVs, since they possess some degree of autonomy.

As with robots in the other services, UUVs come in various sizes, from man-portable to very large. A large UUV, the Seahorse, is advertised as being capable of 'independent operations', which may include the use of lethal weapons. Large UUV programs exist in USA, Australia, Great Britain, Sweden, Italy, Russia, and other countries. As with other military robots, most of the vehicles capable of delivering deadly force are currently human-controlled and not fully autonomous. However, the need for autonomy is great for underwater vehicles, since radio communication underwater is difficult. Many UUVs surface periodically to send and receive messages.

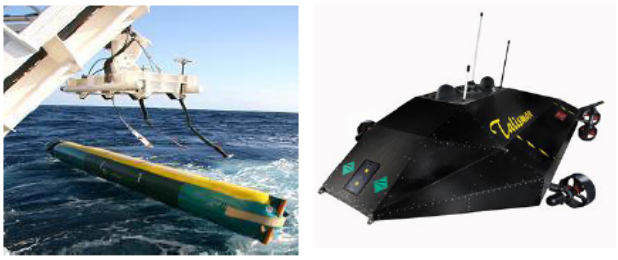

Fig. 3: Marine Robots

Space Robots

It is believed that the US Armed Services have significant programs for the development of autonomous space vehicles: for advanced warning, defense against attacking missiles and possibly offensive action as well. However, there is very little information on these programs in publicly available sources. It is clear that the Air Force is building a major communication system in space, named Transformational Satellite Communication System (TSC). This system will interact with airborne as well as ground-based communication nodes to create a truly global information grid.

Immobile/Fixed Robots

It should be noted that not all robots capable of lethal action are mobile; in fact, some are stationary, with only limited mobility (such as aiming of a gun).

There are immobile or stationary weapons, both on land and on ships, which do merit the designation of robot, despite their lack of mobility. An example of such a system is the Navy's Phalanx Close-In Weapon System (CIWS). CIWS is a rapid-fire 20mm gun system designed to protect ships at close range from missiles which have penetrated other defenses. The system is mounted on the deck of a ship; it is equipped with both search and tracking radars and the ability to rotate a turret in order to aim the guns. The information processing ability of the computer system associated with the radars is remarkable, since it automatically performs search, detecting, tracking, threat evaluation, firing, and kill-assessments of targets. Thus, the CIWS uses radar sensing of approaching missiles, identifies targets, tracks targets, makes the decision to fire, and then fires its guns, using solid tungsten bullets to penetrate the approaching target. The gun-and-radar turret can rotate in at least two degrees of freedom for target tracking, but the entire structure is immobile and fixed on the deck.

The US Army has also adopted a version of the Phalanx system to provide close-in protection for troops and facilities in Iraq, under the name 'Counter Rocket, Artillery, and Mortar' (C-RAM, or Counter-RAM). The system is mounted on the ground or, in some cases, on a train platform.

3.1. Romanian Military R&D Developments

Romania, as part of NATO and EU, follows the trend in this are also. Military Equipments and Technologies Research Agency (METRA) as the main military R&D structure developed several projects at national level or in collaboration with other nations, under the umbrella of NATO Research & Technology Organisation (RTO) and European Defence Agency (EDA).

Following the international trends, METRA developed a functional demonstrator for a soldier system, very often named at international level "Future Soldier" (fig. 4). This kind of programs aims to offer the next generations of dismounted soldiers, which will be the intermediate step between the classic soldier and a fully autonomous fighting robot.

Future Soldier Programs usually creates the framework for developing different kinds of military robots and sensors in order to enhance soldier performances, sensitive capabilities and endurance.

Fig. 4: Romanian Functional Demonstrator for Future Soldier System

Like other countries, METRA in collaboration with different companies from defence industry, developed several robots to fulfil missions like surveillance, reconnaissance, location and disposal of mines and IEDs and to enhance the strength and load bearing capabilities of the soldier.

Regarding ground capabilities there are already finished three robots, two for surveillance and reconnaissance (fig. 5.b and 5.c) and one for location and disposal of mines and IEDs (fig. 5.a). All three robots are electrical powered and last two can be easily fitted in a car trunk. Also there is planned the development of an armed robot with a small machinegun. Also, METRA had developed an exoskeleton to increase soldiers bearing capabilities and relieve part of his equipments burden. This demonstrator still requires a lot of works, but there are hopes that in the future we will have a fully functional system (fig.5.d).

a.)

b.)

c.)

d.)

Fig. 5: METRA's Ground Robots

Regarding aerial capabilities METRA developed a tactical UAV for surveillance and reconnaissance that has a range of approximate 10 km. It is a portable system, light and it takes one man to operate and two for carrying. It can provide live images to dismounted soldiers, vehicles or commanding posts and it has both controlled or autonomous flight capabilities (fig. 6). Next generation planned will have increased range and night vision capabilities.

Fig. 6: METRA's Tactical UAV.

Also in connection with Future Soldier System, METRA developed a Portable observation and surveillance systems and solutions for indoor real time broadcast image (fig. 7). The system's purpose is to locate the people that are in closed spaces. The sphere with the video-audio sensors is thrown or rolled into the interested area in order to observe, monitor, oversee, detect possible threat etc. The sphere is continuously transmitting real time video images with sound to the display unit. The operator is able to see the video images received from the sphere on the display unit and can act accordingly.

Fig. 7: Portable observation and surveillance systems and solutions for indoor real time broadcast image

3.2. Ethical Issues on Robot Use

The use of robots for military purposes raises some new issues that must be recognized in any comprehensive assessment of risks from military robotics. These challenges fall into categories related to law, just-war theory, technical capabilities, human-robot interactions, general society, and other and future issues. For instance, such issues are:

- If a military robot refuses an order, e.g., if it has better situational awareness, then who would be responsible for its subsequent actions?
- How stringent should we take the generally-accepted 'eyes on target' requirement, i.e., under what circumstances might we allow robots to make attack decisions on their own?
- What precautions ought to be taken to prevent robots from running amok or turning against our own side, whether through malfunction, programming error, or capture and hacking?
- To the extent that military robots can help reduce instances of war crimes, what is the harm that may arise if the robots also unintentionally erode squad cohesion given their role as an 'outside' observer?
- Should robots be programmed to defend themselves, given that they represent costly assets?
- Would using robots be counterproductive to winning the hearts and minds of occupied populations or result in more desperate terrorist-tactics given an increasing asymmetry in warfare?

Given these issues, although robotics made impressive progresses, there is still a long way until we will have fully autonomous robots involved in military operations.

4. Conclusions

The use of military robots represents a new era in warfare, perhaps more so than crossbows, airplanes, nuclear weapons, and other innovations have previously. Robots are not merely another asset in the military toolbox, but they are meant to also replace human soldiers, especially in 'dull, dirty, and dangerous' jobs. As such, they raise novel ethical and social questions that we should confront as far in advance as possible—particularly before irrational public fears or accidents arising from military robotics derail research progress and national security interests.

A gap in robotics between military users, industry and research actually does exist. The gap between users and industry is caused partly by some ideas of military users on the way they would like to deploy robots for their tasks still needing to mature, and partly by the approach of industry of developing robots without very specifically digging into military specified needs and requirements. The gap between industry and research is caused partly by industry not being aware of some developments going on in research and partly by research not being involved in and focused on real-life applications of military robots.

Gaps do exist on technological fields of interest like:

1) Communication;
2) Robot platforms;
3) Sensing and world modeling;

4) Navigation and mission planning;
5) Human-robot interaction; and
6) Multi-robot systems.

Without closing the identified gaps, it will not be possible to have well usable robotic support for the military.

5. Acknowledgements

A very special thanks goes out to our colleagues involved in the development of these projects and who supported us with a lot of materials and photos and time.

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