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State of the art military robots and the future of warfare

IV123 Future challenges of informatics

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Introduction

In the last millennia, ancient civilizations, medieval empires as well as modern countries were fighting each other. Thousands of soldiers slaughtered in man-to-man combat in countless battles. Despite new weapons being developed, a man had to always get onto the battlefield and face direct risk. Only the 20th century was the beginning of the new era of warfare – era of unmanned robots. How far will their development go? Or will it continue at all?

History of military robots

Although various attempts to create controlled machines were made throughout the history, the first fully-controlled one was invented by Nikola Tesla in 1898. It was a radio-controlled boat, which he believed could be used for military purposes. However, his idea was rejected.[1]

More ideas were born during the World War I but the only one to get into action was German FL-7 wire-guided motorboat, later equipped with Tesla's radio-control system. Its purpose was, while loaded with explosives, to ram into enemy ships.

In 1930s the first remotely controlled plane "Dennymite" was constructed by Reginald Denny and used as a target for anti-aircraft gunners to practice on. Some vehicles used on battlefields of the World War II were "Goliath tracked mine", a German wire-controlled small vehicle carrying explosives, or the Soviet "Teletank", radio-controlled tank equipped with machine guns and flamethrowers. Both Germans and Allies were experimenting with remotely-guided bombs and planes.

1 http://www.historynet.com/drones-dont-die-a-history-of-military-robotics.htm

After the war, these vehicles weren't needed anymore and the only notable one was the reconnaissance drone "Lightning Bug" by built by Ryan Aeronautical in 1962 and used mostly in Vietnam and China[2].

Until 1990s, all vehicles had to be manually guided by an operator or programmed to follow a specific path. Some were able to reach their destination and come back the same way but all their actions were pre-programmed. Only integration of GPS in 1990s started the new era of military robotics, allowing drones, such as RQ-1 Predator, to be automaticaly navigated with precision and provide more detailed information.

The development of UGVs (Unmanned Ground Vehicle) and UAVs (Unmanned Aerial Vehicle) was accelerated by the war in Iraq and Afghanistan, where the U.S. soldiers had to face a different kind of enemy than they were used to. The ability to reveal IEDs (Improvised Explosive Device) or hidden combatants without risking human lives was suddenly invaluable.

Present military robots

TALON

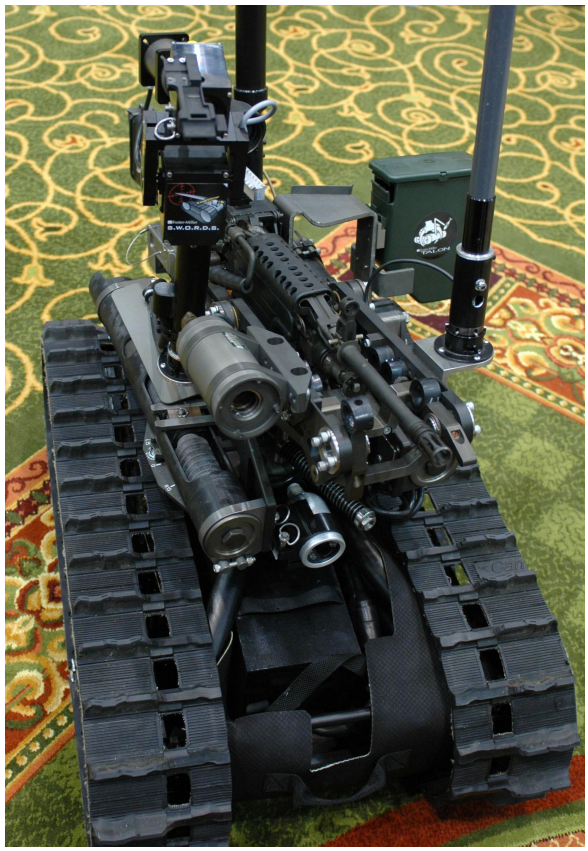
"TALON is a powerful, lightweight, versatile robot designed for missions ranging from reconnaissance to weapons delivery. Its large, quick-release cargo bay accommodates a variety of sensor payloads, making TALON a onerobot solution to a variety of mission requirements."[3]

TALON was originally designed to scout ahead of ground troops and detect and disable improvised explosive devices but its roles were broaden over time. It became one of the most used robots in Iraq and Afghanistan.

2 https://en.wikipedia.org/wiki/Ryan_Model_147
3 http://www.globalsecurity.org/military/systems/ground/talon.htm

SWORDS (Special Weapons Observation Reconnaissance Detection System) is an armed version of TALON, carrying a machine gun or a grenade launcher and serving more for defense purposes rather than offensive actions.

These robots can perform autonomous actions such as return to a previous position if they lose connection but haven't been authorized to automatically attack targets. This is always controlled by a human operator.



Packbot

Packbot could be characterized as a smaller, lighter and tougher version of TALON. Same as TALON, it can be used to reveal and remove explosives but is more suitable for locating enemy soldiers thanks to its endurance and a long arm with a camera allowing it to look through windows or behind corners.

"Controlled by a Pentium processor that has been designed specially to withstand rough treatment, Packbot's chassis has a GPS system, an electronic compass and temperature sensors built in."[4] It also uses flippers to get over obstacles and even stairs. Again, Packbot has to be remotely controlled by an operator.

BigDog

BigDog is a mule-sized robot designated to help soldiers carry loads through rough terrain. It uses four legs to get over obstacles and stabilize itself. A stereo vision system allows it to follow a specific person and to create a 3D model of the terrain surrounding it. *"This model enables the robot to identify a safe path forward, but can also enable BigDog to calculate the distances of any gaps or caverns and whether or not they could be cleared safely with a jump. In laboratory testing, the BigDog successfully jumped 1.1 metres with a full payload."*[5]

4 http://science.howstuffworks.com/military-robot3.htm
5 http://www.army-technology.com/features/featurecould-bigdog-be-a-soldiers-best-robotic-friend/

As a video by Boston Dynamics (the creator of BigDog) shows[6], it can climb up a 35 degree hillside, withstand being suddenly pushed, recover from slipping on ice or run as fast as 5mph. All while fully loaded.

MK 15 Phalanx CIWS (Close-In Weapons System)

Phalanx CIWS is a weapon system mounted on ships providing close-range defense against anti-ship missiles, aircraft and even small boats. Having been introduced in late 1970s, it's being used by many countries after several modifications. It serves as the last line of defense if other defense systems fail and consists of a radar system and a 20-millimetre rapid-fire machine gun. It's fully autonomous, from target acquisition to firing.[7]

6 https://www.youtube.com/watch?v=cNZPRsrwumQ
7 https://www.fas.org/man/dod-101/sys/ship/weaps/mk-15.htm

RQ-11 Raven

One of Small Unmanned Aerial Vehicles (SUAV), provides overview of the battlefield over short range. *"It delivers real-time colour or infra-red imagery to the ground control and remote viewing stations via three different cameras attached to the nose of the plane."*[8]

It can be used to locate and target combatants. Being small sized, it can be carried by a single man and launched off hand. It's easy-to-use and therefore very popular, plus doesn't require any special personnel.

8 http://www.army-technology.com/projects/rq11-raven/

RQ-1 / MQ-1 Predator

Predator is possibly the best-known Unmanned Aerial Vehicle. RQ-1 first flew in 1994 after General Atomics Aeronautical Systems was awarded a contract to develop the Predator system.[9] Predators proved to be useful in various missions but became quite unpopular among the public due to use against civilian targets, killing innocent people and possibly spying U.S. citizens.

RQ-1 was the first version of Predator and was equipped for reconnaissance. It sends imagery from radar, video cameras and an infrared camera to soldiers in action, the ground control station or to any place on the world. It is controlled via satellites and hence can be operated from anywhere. It was first used in Bosnia in 1995 and since then also during other operations in Balkan.

In 2001, MQ-1 was first used by U.S. Air Force. Equipped with Multispectral Targeting System and AGM-114 Hellfire missiles it is able to acquire a target using multiple ways and with extreme accuracy.[10]

9 http://www.airforce-technology.com/projects/predator-uav/
10 http://science.howstuffworks.com/predator4.htm

Predators were mostly used in Afghanistan and Pakistan, often to locate and kill Taliban and al Qaeda leaders. In Pakistan only, these attacks are estimated to have caused 2,000 to 3,500 deaths without any reliable information about the percentage of civilians (ranges from about 250 to 900).[11] [12]

11 http://natsec.newamerica.net/drones/pakistan/analysis
12 http://www.thebureauinvestigates.com/2013/04/02/march-2013-update-us-covert-actions-in-pakistan-yemen-and-somalia/

Ethical Issues

Since modern military robots with some degree of autonomy entered service, many people have been worried about them going off control and, if given full autonomy, not being able to differentiate between enemy targets and civilians or friendly units.

Incidents

Several incidents have already happened. In 1996, the Phalanx CIWS on a Japanese destroyer accidentally shot down a U.S. aircraft during target practice. Both pilots survived.[13] A human error was later found out to have been the cause of this incident.

During a training in South Africa in 2007, a malfunction of an automatic antiaircraft cannon caused 9 deaths and 14 injuries.[14]

In 2011, UAV operators authorized an attack on two U.S. soldiers in Afghanistan as they considered them to be Taliban fighters. It was the first time a UAV killed friendly units.[15] However, a number of accidents involving deaths of civilians have been reported mainly from Pakistan.

These incidents and fear from what future fully autonomous robots would and, more importantly, wouldn't be able to do led to calls for international laws concerning military robots and even a worldwide ban on these robots.

13 http://community.seattletimes.nwsource.com/archive/?date=19960604&slug=2332840
14 http://www.wired.com/dangerroom/2007/10/robot-cannon-ki/
15 http://articles.latimes.com/2011/oct/14/world/la-fg-pentagon-drone-20111014

Acts against the use of autonomous military robots

In November 2012, U.S. Department of Defense issued a directive that doesn't allow use of lethal fully autonomous weapon systems for 10 years. There has to always be an operator, so called "Human-in-the-Loop":

"Autonomous and semi-autonomous weapon systems shall be designed to allow commanders and operators to exercise appropriate levels of human judgment over the use of force."[16]

Human Rights Watch started a campaign in April, 2013 to completely ban what they call "killer robots". Their report[17] deals with inability of robots to avoid civilian casualties and decide when to use lethal and when non-lethal force.

In May, 2013 during the Human Rights Council in Geneva, Christof Heyns, a United Nations independent human rights expert, debated about the use of "lethal autonomous robots" with representatives of countries from all over the world. *"War without reflection is mechanical slaughter. In the same way that the taking of any human life deserves as a minimum some deliberation, a decision to allow machines to be deployed to kill human beings deserves a collective pause worldwide,"* he said during his presentation.[18]

It's expected that further actions will be taken to at least delay the use of autonomous military robots. However, their development still continues and likely won't be stopped. Hopefully, the programmers of artificial intelligence for these robots will take advice from these actions.

16 http://www.dtic.mil/whs/directives/corres/pdf/300009p.pdf
17 http://www.hrw.org/sites/default/files/reports/arms1112_ForUpload.pdf
18 http://www.ohchr.org/EN/NewsEvents/Pages/DisplayNews.aspx?NewsID=13380&LangID=E

The future of military robotics

Challenges of robotic AI

Let's assume robots will be authorized to autonomously search for and attack hostiles. What needs to be done so they follow the Laws of War and Rules of Engagement?

It is almost impossible to develop a flawless system. Especially in the beginning, various mistakes end errors are expected to happen. Who should be responsible? The programmer, the commanding officer or the robot? Lawyers still haven't come to any conclusion but it will likely be judged depending on the particular situation.

What critics are concerned about the most, is how robots will distinguish a combatant from a civilian. By looking for weapons? How to know that a certain object is a weapon and not a camera for example? (Even humans have trouble with that.[19]) What if the subject is hiding among civilians? How to proceed if they have a lock on the target but could harm civilians? When is collateral damage acceptable if at all?

One solution to these problems could be to let only human operators "pull the trigger" but then it could be too late. And the robot present in the action could have better overview of the situation and actually make a better decision than the operator. What if the robot received an order but its sensors suggested that it shouldn't take such an action?

Another solution is to arm the robots with non-lethal weapons and let the operators decide if a lethal weapon can be used. However, a robot might evaluate possible actions faster in a given situation and once authorized to use lethal weapons, it would be too late.

19 http://www.reuters.com/article/2010/04/06/us-iraq-usa-journalists-idUSTRE6344FW20100406

It's not only about hostiles and civilians, though. A human soldier can quickly spot a wounded enemy or one that's about to surrender. How to ensure robots can do the same?

Another disturbing issue is whether a robot should have any right to defend itself. Although it's primary concern ought to be not do any unnecessary harm, once it can make decisions similar to human's, should it also have appropriate rights?

These are just some of the issues that have to be solved if autonomous robots will ever be used en mass. P. W. Singer, a specialist on 21st century warfare covered this topic in great detail in his book *Wired for War: The Robotics Revolution and Conflict in the 21st Century*.

The future of warfare

What will the future wars look like? Again, we need to assume that robotic AI will reach such capabilities that it will be acceptable to bring them to battles. This will likely take decades. Until then, present robotic systems will undergo many modifications and projects in the phase of development and testing will get into action.

This year, the X-47 became the first UAV to take off from a carrier pushing the limits of usability of these planes even further. The Predator's successor, MQ-9 Reaper, is already being used for several years and a new model is in development, meaning even less time needed to deploy more firepower.

These drones don't have to be used for military purposes only, however. For example the ARGUS-IS (Autonomous Real-time Ground Ubiquitous Surveillance-Imaging System) can provide a detailed view over a whole city.[20]

20 https://www.youtube.com/watch?feature=player_embedded&v=13BahrdkMU8

There's also progress in micro-robotics. Several insects with integrated electronic circuits are being tested, making them practically cyborgs ideal for spying missions. Same goes to nanobots, which are now mostly being developed to help humans but it's not hard to imagine they could also deliver death or at least do some spying.

One area that hasn't seen war yet, is the space. The USA already has plans to use special drones that could operate on the border of the space, however. Of course, this is something that needs a lot of consideration as we can't predict what space wars would really cause.

Will we one day see drone-to-drone battles? It is possible, but the future might actually bring two kinds of wars. While robots will still play a key role in conflicts against low-armed insurgents, cyberwar will become much more important. As we've seen in Iran in 2010, a single well-written piece of software is capable of disabling a whole factory. There have also been unconfirmed reports of U.S. drones controlled by the enemy. Future conflicts between highly-developed countries may therefore be fought mainly in front of the computer screens.

Conclusion

In the last years we've been witnessing the beginning of a whole new era of warfare. Era, when a human doesn't have to risk their lives but might risk losing their humanity. Video game-styled controllers and remote control of robots make killing a fun game. Game, that sometimes gets out of hands. Autonomous military robot designers and programmers, or human rights activists, will have to work hard to ensure the Terminator doesn't become reality.