Predators, drones and robofly:
robotics and the military

Chris Langley describes how military interests have become pervasive in robotic science and engineering and outlines the ethical problems this causes.

Introduction

David Webb's incisive article, *From space weapons to basic human needs*, in the last SGR Newsletter covered new military technologies and their uses both within, and tangentially to, the 'battlespace'[1]. He touched upon robotics, the military funding of which and the subsequent use in areas of conflict raises many profound ethical, scientific, political and humanitarian questions.

It is the intention of this article to look in more detail at the uses of robots in the military sphere and to suggest why we should be very concerned with developments in this branch of science and engineering.

Robotics, or 'autonomous engineering', is currently the focus of a wide range of research and development. There are major robotics research centres in the USA and UK – for instance, at the Universities of Bristol, Sussex, Oxford and Edinburgh – and in London there are robotics groups at University College and Imperial College. Support for robotics research and development comes from military and other corporations, the research councils and government departments.

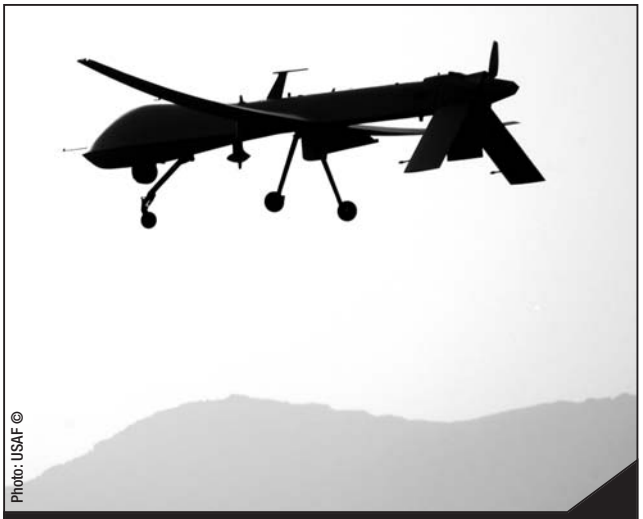
Robotics has been pivotal in supporting the so-called 'Revolution in Military Affairs' (RMA). The main thrust of the RMA is the use of advanced technology to achieve strategic military objectives. It really came to public notice during the 1990-91 Gulf War, and has since been seen in operation in Kosovo, Afghanistan, Iraq and Lebanon[2]. Robotic – that is pilot-less – aircraft have been used in these conflicts for surveillance and to deliver missiles and munitions. There are around 600 currently in operation in Iraq. Many more robotic military vehicles are on the drawing board or are being tested in countries across the world, most notably in the USA and the UK.

From science fiction to reality

Robotics has inspired science fiction and in fact the word came from this literature. Isaac Asimov wrote extensively about robots and their various uses – many of which have become commonplace. His concern with the potential uses of robots led him to coin in 1940 the 'Laws of Robotics', which he revised in 1985[3]. His first law is one to linger over when thinking about the military use, both potential and actual, for robotic devices:

"A robot may not injure humanity or, through inaction, allow humanity to come to harm."

It is this law which the military sector and those they fund in science and engineering are currently challenging in a significant way.



An unmanned Predator aircraft patrols in Afghanistan

One example from many highlights the ethical implications of using robotic aircraft, also known as Unmanned Aerial Vehicles (UAVs). In January 2006 an American Predator drone (a UAV, see photo) fired Hellfire missiles at a house in Bajaur tribal agency in Pakistan, killing 18 people but missing the primary target – a suspected key member of al-Qaeda. Questions about strategic use of such drones, the potential for errors and the involvement of civilians who happen to be in the target zone should cause those contemplating the wider use of such drones to ponder the legitimacy of such powerful weapons platforms.

A number of countries, including the UK and the USA, are putting a great deal of money into military robotics – particularly aircraft like the Predator drone. In 2001 the Pentagon spent $360 million on UAVs. This figure will climb to more than $3 billion by 2010, a trend reflected globally. In 2003 there were almost 400 UAV projects underway in 37 countries[4].

Like the Predator, some of these vehicles have been equipped with missiles. Other robotic aircraft either carry different weaponry or are used for surveillance and related tasks. The Ministry of Defence said in its Defence Industrial Strategy in December 2005 that it was its goal to have pilot-less military aircraft take the place of the human version in the near future. This is a decision reached without public discussion as to the 'need' for such technology in modern theatres of war.

BAE Systems released details in February 2006 of a secret programme of research and testing of such vehicles, quaintly named Kestrel, Raven and Corax[5]. These robot aircraft use sensors and cameras together with BAE's control and guidance software in an integrated way to carry out various military activities.

As was discussed in the SGR report, *Soldiers in the Laboratory*[6], there is a complex interconnectedness between those in science and technology and the military. This produces a variety of technologies which come to dominate military thinking – the RMA owes its place in the security agenda in the USA and UK to the expertise of scientists, engineers and technologists. Robots to replace or assist human beings depend upon this expertise supported by bloated global military spending. As we know there has been a profound increase in US military spending in the last five years, with more than 50% of federal R&D in the USA used for military objectives. The proposed federal budget for US military R&D in 2006 is around US$74.8 billion – to fund four weapons systems including those using robotics engineering[7]. This is in stark contrast with socially useful programmes, which have been cut by the Bush administration.

Robotics – all in the family

Complex networks depending upon satellites are essential to how war is now conceived by the military, guided by the RMA. Robots feed into such systems by supplying information and depending for their operation upon satellite technology such as the

Global Positioning System (GPS). Robots are here assisting the role of humans in warfare by calling upon high technology computational techniques, plus automatic target recognition and robot-led fast identification, to decide who or what to fire at. Margins of error have been shown to be wide. Unfortunately the military in the USA and UK appear not to collect data on such errors in a consistent fashion.

Increasingly modern wars, at least where state players with high technology weapons and their support systems are involved, see the gradual removal in many areas of human overseers, replaced by autonomous robots programmed for specific activities and responses. This is surely cause for concern, especially where civilian casualties are likely to be involved.

The military uses of robotic devices fall under four broad categories. This is a simplification since increasingly military robotics encompasses a variety of different technologies and systems which produce 'smart' weapons, their delivery platforms and ways of disabling the enemy. The four categories are:

- Autonomous Land Vehicles (ALVs);
- Unmanned Aerial Vehicles (UAVs);
- Miniaturised Autonomous Vehicles (MAVs); and
- Enhanced Soldier Technologies.

The land-based ALVs are sensor-enabled robots, capable of being used to enter conflict zones and other areas which are considered dangerous to humans. ALVs range in size from machines as small as an iPod to a device the size of a London bus. The US corporation, General Dynamics, is currently undertaking four research projects to design army ALVs whose functions include: acting as sentinels; overcoming obstacles; and, in the form of 'robocrabs', working underwater. In the UK there are several underwater autonomous vehicles, like Talisman, in the testing phase. If there were suitable innovatory pathways in place both land- and sea-based vehicles might well have important civilian uses.

As discussed earlier, UAVs are the major focus of military interest at present. They are small, lightweight and relatively cheap. UAVs can fly without operator control and there are four or five different kinds at present in operation. UAVs include drones such as Predator, which are remotely piloted. Others include robotic aircraft (with stealth technologies to evade radar) using artificial vision or 'sensory' systems to accomplish pre-programmed tasks. Some carry weapons systems like the Hellfire missiles used in Pakistan. They can patrol borders and be used for many surveillance activities, and not solely in military situations. Hence questions about safety, privacy and human rights loom large here. Such concerns remain largely overlooked in the deployment of UAVs.

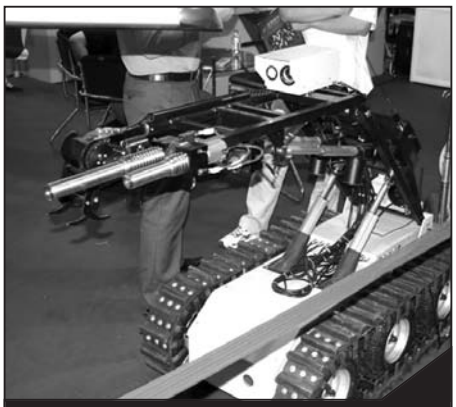


Photo: Steve Wright ©

An 'Autonomous Land Vehicle' at a recent military fair

Photo: Steve Wright ©

The military are increasingly dominant in robot technology

The third category is MAVs, which are small insect-like vehicles which can make use of nanotechnology. Readers of *New Scientist* will have come across such robots over the last few years. Some MAVs have wings, others have wheels. US researchers have proposed MAVs which could be entirely autonomous and designed to make decisions without recourse to a human operator or minder. Swarming like wasps is a proposed feature of such vehicles and this has attracted the attention of NASA and Boeing, working in the $21 billion Future Combat Systems (FCS) Programme.

The primary use of MAVs is to evade radar and attack essential services such as telecommunications and similar network based systems – an impact which would be especially felt by civilians. One such MAV is Robofly, which has sensors and cameras and is destined for patrol tasks in a variety of surveillance operations. Funding for Robofly comes from the US Defense Advanced Research Projects Agency (DARPA) and this supports research at the University of California and the Georgia Institute of Technology (which also enjoys Lockheed Martin funding, a major player in the Missile Defense programme). Robofly and similar clones use GPS for navigation and raise concerns about civil liberties when they are considered for a variety of potential policing roles[8].

Lastly, there are the so-called Enhanced Soldier Technologies which comprise a variety of systems to excite those who enjoy science fiction. This area of robotics is essentially a set of variations on a 'suit' capable of enhancing human activity – it ranges from a single arm device to full body enhancement. This technology appears to be still quite primitive, with research being very well funded in the USA, especially at the Massachusetts Institute of Technology. The situation in the UK is more difficult to unravel.

All these systems share technologies and needs. They also have a number of both military and civilian policing uses. They all use sensors, many make use of GPS and need small power sources, and operationally all the autonomous vehicles demand 'management' of space – here robotics joins the Missile Defense programme being supported in the USA, UK and other countries. There are various military-university partnerships in the UK supporting robotics research and the associated technologies for mainly military objectives[9].

What are the main ethical concerns?

- Disquiet has been expressed by many in the robotics and artificial intelligence communities about the dangers of the speed and extent of robotic development. This has basically centred on how robots with massive processing capability and 'intelligence' might threaten humans – so using these systems within conflict and battlespace situations creates further worries. There has not been any significant public debate over this issue – is this satisfactory?

- Autonomous vehicles and related systems are increasingly able to 'take decisions' without human intervention. Even the best and most widely used are fallible and present risks such as airborne collision, vehicle failure and errors of recognition and location. Thus there are a host of ethical dilemmas about such machines 'deciding' to kill, destroy and make similar choices about legitimate targets.

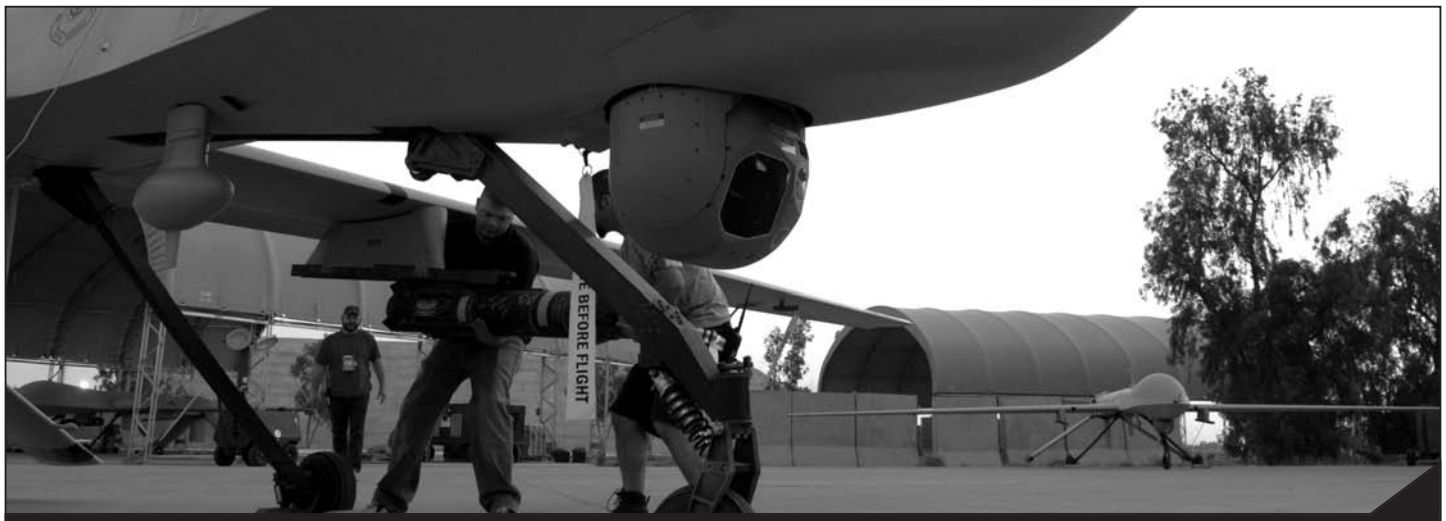


Photo: USAF ©

A Predator aircraft being armed

- Robotics has potentially important non-military uses, for instance sensing and dealing with chemical, physical and biological hazards. But the closure of around 50 university engineering departments in the UK since 1994 reduces available non-military funded, independent robotics research expertise – is this a good idea?

- Many have strongly criticised the move to high-technology warfare enshrined in RMA, which supposedly reduces casualties by relying on ever more technological fixes[10]. But as we have witnessed recently this tends to make war more 'acceptable' as a solution to crises, and hence easier to start, and additionally it tends to drive non-conventional or terrorist responses with consequent impact on civilians. Shouldn't we have a fully informed debate on the trends we are witnessing in warfare?

- Growth of high technology weapons and their support systems within our globalised world drives proliferation. The robot vehicles described are relatively cheap to build and can be easily obtained – and so are attractive to oppressive regimes and terrorist organisations. This calls for strong means of technology management globally, which is largely lacking at present.

- The high levels of funding devoted to military robotics and human-machine interfaces can give rise to high prestige science and technology programmes. This can divert the available expertise away from helping to tackle broader threats to security including climate change, poverty and related issues.

- Military funding, especially of emerging technologies such as the nanotechnologies, can lead to 'lock-in', examples of which include nuclear reactor design and also ruby and glass laser technology. In robotics, this will also favour military utility over civilian needs if the levels and sources of funding remain as at present.

Conclusion

David Webb concluded in his discussion of space weapons:

"The world spends so much on weapons and warfare but it spends very little on technologies that address real human needs."

This is especially true of the funding of robotics. Some redirection of research away from the multitude of existing and potential military uses of autonomous engineering and towards socially useful goals is urgently needed. Although some of the robotic devices described in this article could have civilian uses, often long innovatory pathways must be followed in order to make them available to non-military markets and uses. This has economic and practical consequences and those in robotics research need to be weaned from military support in order to address a variety of global problems. These include post-conflict de-mining and cheap but effective aids for those with disabilities. Robotics is an area which is far too important to be left to the military sector to monopolise.

Dr Chris Langley is SGR's principal researcher and is author of the report, *Soldiers in the Laboratory*.

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10 As [2]