Robotics in Warfare

Lieutenant Colonel Sushil Pradhan*

Introduction

One of the most profound changes in modern warfare is the astonishingly rapid rise in the use of robots on the battlefield. Robots can easily and safely perform tasks that would otherwise endanger human lives, and do so faster and more efficiently than is possible with conventional methods. Military missions can be incredibly boring as well as physically taxing, and robots are proving attractive for roles that fill what are called the three D's (Dull, Dirty, or Dangerous). For example, using the same mine detection equipment as a human, today's robots can do the same task in about a fifth the time and with greater accuracy. They provide extended stand-off and reduced risk of exposure. Military planners have to figure out not only how to use these machines in the wars of today, but also how they should plan for battlefields in the near future that may well be largely robotic. This paper explores the military application of robotics in future battlefield scenarios.

Why Battlefield Robots?

Militaries around the world are offloading their hazardous and exhausting tasks to robots. Humans lose effectiveness after ten to twelve hours. They simply wear down physically and psychologically from doing the same task that long. Unmanned systems, in contrast, do not need sleep, food or recreation. Certain battlefield tasks require incredibly high concentration, which is difficult for humans to sustain for long periods of time. Robots need to take breaks only for recharging or refuelling, and the repetitive nature of complex, dangerous activities does not affect their efficiency or efficacy. Robotic systems can also operate in environments contaminated by biological, chemical or radiological weapons, where a human would have to wear a bulky suit and protective gear. They can sustain extremes of operating situations,

---

***Lieutenant Colonel Sushil Pradhan** was commissioned into the 5th Battalion, the Mechanised Infantry Regiment (14 Kumaon) in 1990. Presently, he is Colonel Administration at the Mechanised Infantry Regimental Centre, Ahmednagar. He won the Second Prize in the COAS Essay Competition 2010 and is a regular contributor to professional journals.

Journal of the United Service Institution of India, Vol. CXLI, No. 588, April-June 2012.

like high 'G' turns that can render aircraft pilots inoperative. Unmanned systems can fly faster and turn harder. This is equally true at sea, and not just in underwater operations, where humans have to worry about small matters like breathing or suffering ruptured organs from water pressure. For example, small robotic boats have already operated in 'sea-state six', which is when the ocean is so rough that waves are eighteen feet high or more, and human sailors would suffer serious physical injury from all the tossing about.

Working at digital speed is another unmanned advantage that is crucial in risky situations. As the Observe-Orient-Decide-Act (OODA) loop gets shorter, there may not be any time in it for humans. For example, humans can only react to incoming mortar rounds by taking cover at the last second, whereas 'R2-D2', the Counter Rocket Artillery and Mortar (CRAM) system deployed in Iraq by the US, could detect and shoot them down before they arrived at the target. Robots also offer quicker learning curves. Robots can be networked via a wire or remotely, which means they have sharable intelligence. A critical difference between battlefield robots and humans is the fact that robots have no psychological needs, no emotional dilemmas and cannot be subverted.

Two crucial factors continue to enhance the appeal for military robots. Firstly, technology has finally matured to the point where reasonably affordable robots can actually do something useful. Secondly, the global security situation has changed for the worse in terms of the variety, sophistication, and lethality of the various threats; thereby presenting the conventional military's answer to the 'suicide bomber'.[1] Thus, while there are varied and multifarious reasons for militaries to adopt robotic systems, it boils down to the realisation that *we can do more with machines on the battlefield than we can do without them.*

Understanding Military Robotics

Robots are man-made devices capable of sensing, comprehending, and interacting with their environment. They achieve the functionality of an artificial organism due to their three pronged structure. They are composed of 'sensors' that monitor the environment and detect changes in it, 'processors' or 'artificial intelligence' that decides how to respond, and 'effectors' that act upon the environment in a manner that reflects the decisions. They need not necessarily be mobile, but this is often a crucial requirement for battlefield robots. More often than not, the armed forces are exploiting the technology of unmanned vehicles, whereas static robots are more widespread in industrial or other applications. *'Unmanned systems'* is the terminology commonly used to describe military robots.

The relative independence of a robot is a feature of 'autonomy'. Autonomy is measured on a sliding scale from direct human operation (remote-control) at the low end to what is known as 'adaptive' at the high end. A machine is adaptive when it can learn; it can update or change what it should search out, even evolving to gather information in new ways.

With the rise of more sophisticated sensors that better see the world, faster computers that can process information more quickly, and most important, GPS that can give a robot its location and destination instantaneously, higher levels of autonomy are becoming more attainable, as well as cheaper to build into robots. But each level of autonomy means more independence. It is a potential good in moving the human away from danger, but also raises the stakes of the robot's decisions.

Applications of Robotics in Warfare

Militaries are fielding robotic systems in rapidly increasing numbers across all domains: air, ground, and maritime. Robots provide diverse capabilities across the range of military operations: environmental sensing and battle-space awareness; chemical, biological, radiological, and nuclear (CBRN) detection; counter-improvised explosive device capabilities; port security; precision targeting; and precision strike. Furthermore, the capabilities provided by these unmanned systems continue to expand.

Unmanned Aircraft Systems. Unmanned aircraft systems (UAS) or Unmanned Aerial Vehicles (UAVs) have experienced explosive growth in recent history and have proved to be an invaluable force multiplier. UAS can provide both a persistent and highly capable intelligence, surveillance, and reconnaissance (ISR) platform to troops requiring a look "beyond the next hill" in the field or "around the next block" in congested urban environments and, if necessary, also assist troops in contact or perform strike missions against high value opportunity targets. UAS are playing a greater role in strike missions for time-critical targeting. One of the most familiar UAV is the Predator. At 27 feet in length, it can spend up to 24 hours in the air, at heights up to 26,000 feet. Predators were originally designed for reconnaissance and surveillance, but are now armed with laser-guided Hellfire missiles. In addition to its deployments in Iraq and Afghanistan, the Predator, along with its larger, more heavily armed sibling, the Reaper, has been used with increasing frequency to attack suspected terrorists in Pakistan by way of cross-border strikes.

Medium-sized drones such as the Shadow can circle at heights above 1,500 feet, to monitor suspicious activity. 44-foot-long jet-powered Global Hawks zoom across much larger landscapes at 60,000 feet, monitoring electronic signals and capturing reams of detailed imagery for intelligence teams to sift through. Each Global Hawk can stay in the air as long as 35 hours. The smaller class UAVs have proven their worth at tactical level, giving short-term line of sight ISR capability to units and also extending the reach of perimeter defence. Small UAVs such as the Raven, which is just over three feet long, or the even smaller Wasp (which carries a camera the size of a peanut) are launched by individual soldiers and fly just above the rooftops, transmitting video images of what is down the street or on the other side of the hill. These smaller, less expensive UAVs have become an integral and essential tool for ground forces and have proliferated throughout the operational environment.

Unmanned Ground Vehicles. Unmanned ground vehicles (UGVs), while not as prolific or at the investment level of UAS, nonetheless have proven their ability to contribute to combat operations. Since operations in Iraq and Afghanistan began, more than 8,000 UGVs have been procured and deployed. They are most effective in defeating IED systems, explosive detection, area/route clearance and Explosive Ordinance Disposal (EOD). They are also used for beach, CBRN and target reconnaissance; and increasingly for logistic support and resupply. About the size of a lawn mower, the PackBot is an EOD robot that mounts cameras and sensors, as well as a nimble arm with four joints. Another widely used EOD version is the TALON, but it has also been remodelled into a "killer app," the Special Weapons Observation Reconnaissance Detection System, or SWORDS. The new design allows users to mount different weapons on the robot including an M-16 rifle, a machine gun, and a grenade or rocket launcher and easily swap them out.

A new robo-soldier is the MARCBOT (Multi-Function Agile Remote-Controlled Robot). One of the smallest but most commonly used robots in Iraq, the MARCBOT looks like a toy truck with a video camera mounted on a tiny, antenna-like mast. This miniscule robot is used to scout for enemies and to search under cars for hidden explosives, and has been rigged with Claymore directional mines. A different version is called the REDOWL (Robotic Enhanced Detection Outpost with Lasers), which uses lasers and sound detection equipment to find any sniper who dares to shoot at the robot or accompanying troops, and then instantly targets them with an infrared laser beam. The MAARS (Modular Advanced Armed Robotic System) carries a more powerful machine gun, 40mm grenade launchers, and, for nonlethal settings, a green laser 'dazzler', tear gas, and a loudspeaker to warn any insurgents that resistance is futile. There are various programs to convert existing manned vehicles into UGVs.

Not all ground robots will take on combat roles. An early entry into the "medbot" field is the Bloodhound. Whenever a soldier is hurt, an alert will go out and the robot will find the wounded soldier on its own. Then the robot's human controller, who might be located anywhere in the world, can check out the casualty via the video link and treat him using the robot's onboard medical payload. REV, the Robotic Evacuation Vehicle (a robot version of an ambulance), carries REX, the Robotic Extraction Vehicle, a tiny stretcher bearer that zips out to drag soldiers into the safety of the ambulance.

A Multifunction Utility/Logistics and Equipment Vehicle (MULE) which is likely to be a pack-animal type quadruped[2] that will do everything from carrying equipment and supplies to mounting its own weapons, such as a machine gun or rockets. Already in service as the BigDog[3], it is 3 feet long, stands 2.5 feet tall, and weighs 110 kg, about the size of a small mule. It is capable of traversing difficult terrain, running at 6 km/h, carrying 150 kg, and climbing a 35 degree incline. Designed to serve as a robotic pack mule to accompany soldiers in terrain too rough for conventional vehicles, BigDog uses four legs for movement instead of wheels or treads, allowing it to move across surfaces that would defeat wheels.

Unmanned Maritime Vehicles. Unmanned maritime vehicles (UMVs) present new opportunities to augment naval forces. Unmanned surface vehicles (USV) have been used at sea in ISR missions and for fleet familiarisation. USVs, along with UUVs, will have an important role in the conduct of Mine Counter-Measures (MCM) as they are particularly well suited for the 'dirty - dull - dangerous' tasks that MCM entails. They provide persistence, which permits significant mine hunting and sweeping coverage at lower cost by multiplying the effectiveness of supporting or dedicated platforms. Additionally, they provide the potential for supporting an MCM capability on platforms not traditionally assigned a mine warfare mission.

Small unmanned undersea vehicles (UUVs) were considered the main workhorses of the mine clearing effort during Operation Iraqi Freedom in 2003 and were used in support of Hurricane Katrina recovery operations in 2005. In addition to Anti-Submarine Warfare (ASW) and hydrographical survey, they can assist in maritime security by way of port surveillance, ISR, electronic warfare and support to Special Operations. Robotic planes and helicopters have been designed to take off from surface ships or launch underwater from submarines. A submarine launching a UAV that can fly in and out of the water (like the Cormorant) extends the mother-ship's reach farther, even ashore.

Military Robotics Developments in India

Realising the potential of robotic technology for military purposes, India is actively pursuing the development of robots through its Defence Research and Development Organisation (DRDO) and select public sector enterprises. Centre for Artificial Intelligence and Robotics (CAIR) was established in Oct 1986.[4] Its research focus was initially in the areas of Artificial Intelligence (AI), Robotics, and Control systems. In 2000, R & D groups working in the areas of Command Control Communication and Intelligence (C3I) systems, Communication and Networking, and Communication Secrecy in Electronics and Radar Development Establishment (LRDE) were merged with CAIR.

Since the last few decades, DRDO, Hindustan Aeronautics Limited (HAL) and Aeronautical Development Agency (ADA) are involved in the development of a range of UAVs/UCA.[5] 'Lakshya', the indigenously-developed pilotless target aircraft was inducted into the IAF in 2005. DRDO is also involved in developing the know-how for a swept wing, stealth design and composite construction technical demonstrator that will demonstrate the technical feasibility, military utility and operational value for a networked system of high performance weaponised UCAVs.[6] DRDO's Research and Development Establishment (Engineers) in Pune, has developed a Remotely Operated Vehicle (ROV) called 'Daksh', manufactured by a consortium of firms and in use with the army. 'Daksh' is an electrically powered and remotely controlled robot used for locating, handling and destroying hazardous objects safely. It is a battery-operated robot on wheels and its primary role is to recover bombs. It locates bombs with an X-Ray machine, picks them up with a gripper-arm and defuses them with a jet of water. It has a shotgun, which can break open locked doors, and it can scan cars for explosives. 'Daksh' can also climb staircases, negotiate steep slopes, navigate narrow corridors and tow vehicles.

DRDO is experimenting with robot mules to carry arms and equipment in difficult terrain and high altitude.[7] Autonomous underwater vehicles capable of carrying out multiple tasks are also being developed. A UGV for nuclear biological and chemical (NBC) surveillance operations is under development at VRDE, Ahmednagar, and will be ready for trials in a year.[8] 'Netra' UAV is being developed for surveillance and recognisance operations for counter-terrorist operations in urban as well as jungle terrain. 'Netra' is set to enter into the production phase following successful user and field trials, including those in high-altitude. R&DE (Engineers) is also developing a gun-mounted robot (light machine gun and grenade launcher), which can be deployed in anti-terrorist situations. While DRDO has mixed results in designing and prototyping, it falters in converting the technology into production. Collaboration with PSUs, academic institutions (like IITs) and private sector firms is the solution if we want to develop military unmanned systems seriously.

Ethical and Moral Issues

Despite all the enthusiasm in military circles for the next generation of unmanned vehicles, ships, and planes, there is one question that people are generally reluctant to talk about. What happens to the human role in war as we arm ever more intelligent, more capable, and more autonomous robots? The point is not that the machines are taking over, but that what it means to have humans 'in the loop' of decision making in war is being redefined, with the authority and autonomy of machines expanding. The reality is that the human location 'in the loop' is already becoming that of a supervisor who serves in a fail-safe capacity in the event of a system malfunction. The expansion of robotic intelligence and autonomy raises profound questions of what roles are appropriate to outsource to machines.

Whether it's watching wars from afar or sending robots instead of humans into battle, robotics offers the lure of riskless warfare. Moving soldiers out of harm's way may save lives, but the growing use of robots also raises deep political, legal and ethical questions about the fundamental nature of warfare and whether these technologies could inadvertently make wars easier to start.

Can robots be programmed to act ethically in war? Researchers are attempting to develop rules of engagement for battlefield robots to ensure that their use of lethal force follows the rules of ethics (or trying to create an artificial conscience).[9] Stress does not affect a robot's judgement the way it affects a soldier's, so theoretically a set of rules can ensure that humans are not unethically killed in the battlefield. Even if ethics can be neatly encoded in software, ISR data can be deceptive, while conditions and situations can change. Will the use of robots lead to wars breaking out more easily? Technologies such as unmanned systems can be seductive, feeding overconfidence that can lead nations into wars for which they aren't ready. The expansion of robotic intelligence and autonomy raises profound questions of what roles are appropriate to outsource to machines. These decisions must be made based not only on how effective the robots may be in battle but also on what this shift in responsibility would mean for their human commanders and the broad political, ethical and legal responsibility for their conduct.

Conclusion

Robots are a critical component of 21st century warfare. Already, unmanned systems are replacing human pilots and soldiers in some roles, and in the future they will take over many more. Battlefield reports the world over highlight the value of unmanned systems in the modern combat environment, especially their inherent features like persistence, versatility, and reduced risk to human life. The benefits of removing human soldiers from harm's way are obvious. Can war be fought by lots of well-behaved machines, making it 'safer for humans'?

In the near future, military robots will include semi-autonomous and autonomous systems that rely exclusively on sensors and computer technology, not human operators, to complete missions. Today's PackBots, Predators, and Ravens are relatively primitive machines. The coming generation of "war-bots" will be immensely more sophisticated, and their development raises troubling new questions about how and when we wage war. The exponentially increasing use of robotics on the modern battlefield challenges our current understanding of technology and war.

Endnotes

1. PW Singer, 'Wired for War: The Robotics Revolution and 21st Century Conflict', Penguin, 2009, p. 64.
2. PW Singer, 'War of the Machines: Robots Transform Battles', Scientific American, July 2010.
3. Jon Cartwright, 'Rise of the robots and the future of war', The Observer, 21 November 2010.
4. http://drdo.gov.in/drdo/labs/CAIR.
5. Ajay Lele, Strategic Technologies for the Military: Breaking New Frontiers, Sage Publications, New Delhi, 2009, p.60.
6. Ravi Sharma, 'India Joins Select Group to Develop UCAV Technology', The Hindu, 27 August 2007.
7. S Sujata, 'DRDO robots to fight future wars', Asian Age, 12 Dec 2011.
8. Vishwas Kothari, 'DRDO plans 500-cr unmanned vehicle project for Indian Army', Times of India, 20 December, 2011.
9. Robot Wars, The Economist Technology Quarterly, 09 June 2007.