Existing applications of autonomy in militaries across the world

Technology, Artificial Intelligence

This term paper dissects existing applications of autonomy in militaries across the world, their limitations and scope for the future. This paper will attempt to paint a picture on what militaries of the future would look like, and have an insight on policies regarding ethical and safe integration of autonomous weapon systems. The methodology used in the term paper will look at AI in militaries from four major perspectives: Technology, Capabilities, Drivers and Innovation Ecosystem.

AI is a technology which enables the possession of intelligence or intellect by computer systems. It exists in contrast with Natural Intelligence (NI), possessed by humans or animals. AI allows machine to achieve objectives that would require human intellect under ordinary circumstances, such as decision making and perception (visual or physical).

From a military perspective, AI as a technology is not a weapon. Rather, it serves as an enabler which holds a lot of promise and might just bring about a revolutionary change to modern warfare. It holds the power to change warfare from it’s present ‘ informatized’ form to an ‘ intelligentized’ form.

AI is a promising technology and has seen extensive research on it’s applications to the battlefield. Experts believe that leadership in AI is essential to maintain or earn global power in the 21st Century. AI is important due to its ability to increase accuracy and efficiency in everything from payload delivery, to logistics. Improved decision making of systems with AI will substantially reduce operational costs and risks to the lives of the soldiers. Technologies like face and voice recognition would provide invaluable intelligence to security forces and would be a game changer for

national security. Most importantly, AI would help optimize the performance of existing military equipments, for example, fighter jets would be able to maneuver better in the absence of a pilot, will possess greater range and would be capable of carrying a higher payload.

For nations like the USA, integration of AI systems into its military protocols would allow them to maintain their military superiority, while China, Russia, India may use the same to introduce their own superiority through technological supremacy. Thus AI in will prove to be a formidable force of the future, determining the geopolitical landscape in the years to come.

Definitions: automated and autonomous

To better understand AI and its capabilities, it’s important to define and differentiate between automated and autonomous technologies.

Automated systems typically operate on a if-then-else rule structure and for each input there will be the same system output until or unless something malfunctions. Example: Land Mines.

Autonomous systems on the other hand, reason probatistically for a given set of inputs. That is, they work out the best set of possible outcomes for a given set of data inputs. Unlike automated systems, autonomous systems may not give the same output for the same inputs and will tend to produce a range of behaviours.

Military applications of AI

Computational Military Reasoning: Using AI to understand and solve human-level military problems, and battlefield decisions.

Lethal Weapon Systems (Unmanned): Development and operation of unmanned air, sea and land platforms for applications in warfare.

Intelligence Analysis: AI systems through their precision and speed may prove effective in analysis of intelligence inputs and thus improve situational awareness.

Present understanding of autonomy

Autonomy can be defined as a machine's ability to perform tasks in absence of humanity's presence. To truly classify a system to possess autonomy, the following three dimensional approach may be taken:

Human-Machine Command-Control Relationship

This dimension deals with the humanity's involvement in operating of systems with autonomy. These systems are divided into the following three types.

Semi-Autonomous System: Systems that require human inputs.

Human-Supervised Systems: Systems which do not require inputs by humans to operate but supervision is provided to account for cases of malfunction or failure.

Fully Autonomous Systems: Systems which operate on their own without human contribution.

Sophistication In Decision Making

This approach deals with the ability of a machine to exercise command over its own operations. From this standpoint, we may divide these systems into three different forms: automatic, automated and autonomous. Automatic

refers to the provision of mechanical response to sensory inputs through predefined protocols. On the other hand, machines that are capable of accomodating for changes in their environment as well as a considerable level of self-governance may be called autonomous.

Types of Functions Being Made Autonomous

This dimensions states that properties of a system in reference to autonomy, depend on each function in particular. Therefore, functions like navigation could designed to achieve autonomy without any ethical or strategic risks and yet achieving autonomy in targeting systems may be more concerning.

Machinery of Autonomy

Machinery deals with obtaining data and using it for various actions, the data may be obtained from the environment. 3 fundamental capabilities are essential. The fundamental capabilities are – Sense, Decide, Act.

Sense – To attain autonomy, effective perception of the environment through a variety of sensors is essential. These sensors will obtain data from the environment. It must also use a sensing software to interpret this data suitably. Target detection, for example, relies on pattern detection. Wherein the system deciphers patterns from a given data set, compares them to the predefined patterns stored in it’s computer memory and detects the target accordingly.

Decide – The data from the sensing software is input for decision making. The course of action may differ greatly depending on the system’s perception of its environment. For example, a Main Battle Tank’s target

acquisition may detect aerial threats approaching it, once the tank commander authorizes retaliation, the tank's anti-air weapon system may decide it's approach depending on factors like wind speed, altitude and velocity of target, humidity and so on.

Act – Upon the completion of the decisions process, the system exerts its control in the real world by physical or computational means.

The decision making models may be reactive or deliberative. The reactive model contains prescribed instructions on how the system must behave in the face of given input sets. For example, in a landmine, the prescribed rule may be that if weight from the range of 70-100 kgs is exerted on it, then it must detonante.

The deliberative model of decision making understands it's environment in mathematical terms and is more complex than the reactive model, it possesses the capability of governing its own actions through the manipulation of data structures and tends to measure the consequences of actions, along with the extent to which it can achieve the desired goals. Taking the example of a beyond-visual-range air-to-air missile (let's consider the USA developed AMRAAM or Advanced medium range air-to-air missile), it's homing system will track a target and use various sensors to calculate the fastest and most efficient manner in which to approach and consequently have good effect on target.

Underlying Technology

At a fundamental level, the following must be implemented:

Sensors, which allow the system to gather data from its environment.

Computer hardware/software, to interpret the date suitably for future actions.

Interfaces for interaction with other machines.

Actuators and end-effectors.

Limitations to Perception, Decision Making and Actuation

The following are the existing limitations and obstacles as faced by a system when it perceives, decides or acts:

Perception – Improvement in perception is a major obstacle for AI today. While sensory perceptions of machines have improved greatly, they are suitable only for patterned environments. It is easy to fool machines with their current ability to perceive, hence can only be applied in limited battlefield scenarios.

Decisions – Another limitation is that of synthetic reasoning. Machines operate on deductive reasoning while humans operate on inductive as well as abductive reasoning. Severely limiting a machine’s capability of making complex determinations.

Actuation – Limitations in actuation are derived from the limitation in hardware technology, with power sources being a major hindrance. Many weapon are unable to operate, due to hardware limitations. Present State Of Autonomy In Weapon Systems

Extensive research show that militries across the world have already integrated their capabilities with autonomous systems on multiple platforms.

Autonomy In Mobility

Mobility has seen the most integration of autonomous system across the world. Mobility can be broadly divided into 3 functions, homing, navigation and take-off/landing.

Homing is applied to missile technology and is fundamentally a form of self direction. Homing capabilities of missiles have improved such that they can track and destroy targets from beyond the visual range of any human. Missiles with modern homing technology are often characterised as ‘ fire and forget’ as upon release, the probability of the missile hitting the target is almost a certainty, unless effective countermeasures are deployed in time. Systems may also include ‘ sense-and-avoid’ technology to prevent any unwanted collisions.

Autonomy in navigation is another essential function. It is the system’s capability to be conscious of it’s position, to track and manage it’s route. Most navigation systems today require at least some parameter definition by humans. Most commonly, navigation systems are given checkpoints, based on which they find the most suitable route on their own.

Autonomous take-off and landing capabilities are becoming increasingly popular in aerial systems. These systems are more automatic than autonomous as they operate on extremely strict parameters and predefined

rules. It is believed that the technology for automatic take off and landing will soon surpass human capabilities in terms of accuracy and success rate.

Autonomy For Intelligence

Detection of explosives is a capability mainly found with EOD (Explosive ordnance disposal) units. They operate robotic systems which attempt to detect, diffuse or even detonate explosives without human intervention, other than fundamental command and control in relative safety. Recent systems have shown capability of carrying out the entire process from detection to detonation without any human interference.

Detection of perimeter intrusion is carried out by unsophisticated systems that use sensor suits to detect any movement along the perimeter of a military installment. Reducing the requirement of sentries and increasing the general situational awareness. The detection of gunfire or other weapons fire is another feature possessed by military robots.

Autonomy In Interoperability

Interoperability is the ability of troops, their equipment and support weapon systems deployed, to operate as an integrated fighting force and in conjunction with each other.