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Is It Sensible to Grant Autonomous Decision-Making to Military Robots of the Future?

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Abstract— **Human-Robot Interaction: to what degree can a military leader leave the robot to act on its own as opposed to the margin left for human decision-making in combat? This article covers our understanding of autonomy and the opportunity military leaders have in using autonomous military robotic systems in field operations. There is a pre-condition: all machines, including autonomous lethal robotic systems, must remain under the tactical control of the military leader. S/he decides and defines military objectives and is always accountable for their use.**

Keywords: Military robotics; LAWS; armed robots; robots autonomy; artificial autonomy; decision-making process; artificial neural network; artificial intelligence; legal autonomy; ethics.

I. INTRODUCTION

France chaired the United Nations Convention on Certain Conventional Weapons (CCW) in 2013 and, following her request, it was decided that an expert meeting on Lethal Autonomous Weapon Systems (LAWS) would be held thereon, on a yearly basis, at the CCW in Geneva. Indeed, as NGOs are expressing growing concerns that autonomous weapons of the future will be incorporating the recent developments of artificial intelligence, the CCW has been under pressure to address the issue of the lawfulness of LAWS which exist, according to Thierry Berthier, since they already equip certain units of the Russian Army [1].

In December 2016, the CCW called on a group of governmental experts – including military, judicial and diplomatic authorities - to discuss legal and ethical issues posed by LAWS recognising that the requirements of International Humanitarian Law are relevant to give a normative framework to their recommendations.

However, if public opinion generally perceives lethality as the key characteristic of future weapon systems like LAWS, the concept of autonomy in general sets a new issue for the military: the machine's level of autonomy a military leader can allow versus the room left for human decision-making in combat.

This is because robotic systems used on battlefields today, and even more tomorrow, are increasingly digitised and interconnected, bringing new opportunities which will transform the art of waging war: by deporting sensors and actuators, in creating a robotic screen ahead of the forces and covering a much larger area, all with a far higher reactivity to that of a human. Hence, what is the freedom of decision a military leader can grant to such a system at the heart of a battle?

II. DEFINITION

What is a military robotic system? Referring to most characteristics mentioned by Catherine Tessier [2], it's a system comprised of one or several military robots. A military robot per se is a mobile platform integrating sensors and actuators, operating in an unknown or unstructured environment, capturing and interpreting data, taking suitable decisions and undertaking the necessary actions in its environment. The decisions it takes are organised to match pre-determined objectives and not just reacting to events. Such objectives are established by the soldier employing it.

III. WHAT IS AUTONOMY?

The military robot is a tool at the service of the combatant, a tactical pawn for the one using it. Today, most robots operating in the military field are teleoperated ones, remotely controlled by an operator at a distance, giving the operator little leeway and increasing his/her vulnerability if she/he is an offboard combatant. In other words, it's remote action under the constant control of the operator.

Certain operating sequences can be automatically processed. An automated system should process well-defined tasks, immediately linking perception and action without human intervention. The algorithm triggering an action is relatively simple: in a sense, it reacts to stimuli following pre-programmed steps by the manufacturer. The results of such an action are quite predictable because automated systems cannot innovate, leaving no room for surprises and/or variations. They execute a well-defined computer code. A good example of this is the robot's capacity for automated trajectory tracking: with its target sight moving, it automatically corrects its position.

For an autonomous system, the level of abstraction in decision-making is higher. It needs a process for decision-making based on a loop of perception-decision-action. The "decisional" part is nonetheless complex because several parameters must be considered including, inter alia, imposed rules and constraints, executing planned tasks, and evaluating the results of actions taken [3]. An analysis of these results can then be integrated back into the system to improve its future behaviour, like that of a learning process. Concerning a system's movements, an autonomous patrol robot, for example, will be able to execute assigned tasks (patrolling the central base and the surrounding area) and continue its mission despite a change of environment (night and day in all weather conditions), despite unforeseen events (avoiding obstacles along its way) and imperatives (giving priority to military vehicles, returning to base to recharge a low battery and leaving again, complying with instructions, etc.). For a soldier, it's clear that machines bring tactical advantages and increase his/her effectiveness. Nonetheless, the lesser the constraints in controlling and operating them, the greater the freedom for the soldier to act. S/he is therefore naturally interested in giving some form of autonomy to the tools s/he uses, such as robots are, under the condition of retaining control over them.

IV. Different Types of Autonomy

Autonomy is also a relation between two agents: the robotic agent and the human agent. There are many degrees of sharing autonomy between the two: a continuum process from situations where a human makes all the decisions to situations where they are entirely delegated to the robot.

The different degrees of autonomy for robots or robotic systems can be classified by an incremental approach:

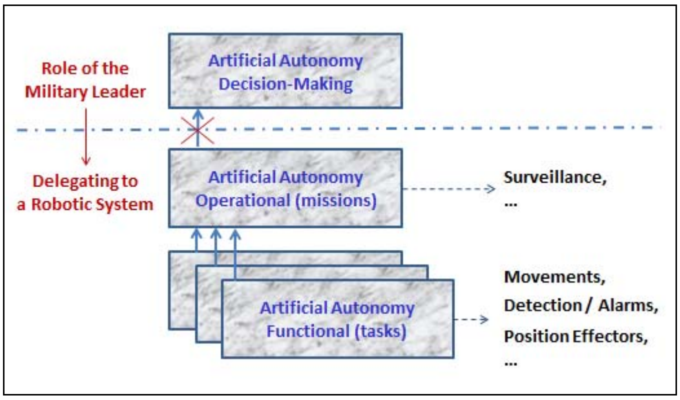

Figure 1 – The different degrees of autonomy for robotic systems

- A functional (or task) autonomy granting a robot an autonomous perception of its environment, the possibility to adapt itself and decide alone the actions it must perform. The function is simple and generally serves one purpose only. To illustrate, such are the autonomous functions of moving, recharging in energy, guiding effectors depending on the threat, etc.;
- An autonomy in robot mission execution where there is no human intervention during the time of the mission. The mission itself is much more global in its enterprise, corresponding to the sum of functional autonomies initiated at the same time and running simultaneously for the same objective, i.e. the mission;
- An autonomy in decision-making and in setting its own objectives, without the intervention of a military leader. This will be discussed later because this form of autonomy shall only remain proper to military leaders. Additionally, it is of no interest to the military in general if a leader hasn't the possibility to decide and define the objectives that are assigned to the robotic system;
- A legal autonomy implying the machine has a legal status with automatic rights. In the military world and most probably in the civilian one as well, such a notion will logically result in rendering an operator totally unaccountable. Furthermore, if one compares this example with that of an animal having an autonomy of its own, the animal will always remain under the responsibility of its master and is legally considered as tangible personal property. The same should apply to any robot of the future.

V. The How and Why of Autonomy and its Perception

Recent digital technologies have generated machines with computing and processing capabilities, including very high levels of precision and speed, that are both far superior to what humans can achieve. This has been possible by using powerful microprocessors and by having access to huge databases. Following the measure for computer performance, several super calculators have reached processing speeds of 10^{15} instructions per second (FLOPS) in 2016 and similarly, databases have grown incredibly: the size of an SQL database today can reach the size of 500 petabytes (10^{15}). Their computing speed enables near real-time reactivity which in turn enables the military to face key constraints, where reaction and initiative are of paramount importance. They could be automatic machines, for example, with the ability to counter missile launches against our armies where human reactivity times are unquestionably too low.

Behaviour will, nevertheless, not be labelled as autonomous just because it is highly reactive. In this case, it would be defined as an automatic behavioural pattern or an auto-response pattern because these machine processing systems always rely on predictive algorithms.

A system's autonomy is primarily provided by the perception of its behaviour which, unlike automation, cannot be fully defined in advance in its execution; and, it's the unpredictable behaviour of this system in executing tasks or a mission that leads to the notion of autonomy. Moreover, a set of automatic processes activated in parallel can then give the impression of a certain autonomy.

More importantly, it's the introduction of artificial intelligence in the decision-making process that is shaping a machine's autonomy or, in some measure, making it artificially autonomous. At the core foundation of artificial intelligence, artificial neural network modelling can be found. In short, each neuron is interconnected with other neurons via synapses. Each synapse is assigned a "synaptic weight" or a coefficient that can see its value evolve depending on the learning process it has gone through. The neurons are connected to successive layers and each one possesses multiple inputs originating from lower layers. When stimulated, it calculates the sum of its inputs, each of these multiplied by its corresponding synaptic weight, using a combination function. It then applies this sum to an activation function which normally provides a binary output.

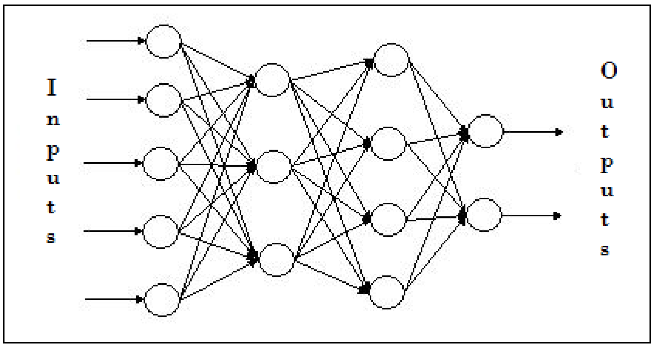

Figure 2 – Artificial Neural Network (ANN)

Yet, each neuron composing a neural network is originally a virgin neuron. The "weights" defining them need to be "educated" or trained depending on what the expected output is. The notion of learning appears at this level and "customises" the robot. To illustrate, at the input of a neural network, pictures of an enemy tank with its key features such as its shape, specific contour, etc. should be shown over and over again. The robot is then made to learn and memorise the pictures repeatedly to adjust the "synaptic weight" of its artificial neural network with the result that it can always precisely detect this type of tank and not mistake it with other types of tank. This suggests that each "weight" converges to a value providing a categorisation which is as close as possible to the one required.

Artificial intelligence contributes to the perception of artificial autonomy. In fact, with complex neural networks, it's no longer possible to exactly anticipate the machine's decision-making process, a fortiori with new types of algorithms, so-called "deep learning" algorithms, now combining computing power with different layers on so-called "deep networks". Thus, if one doesn't precisely know how a machine fitted with such networks has been trained, then it will be difficult to determine its exact behaviour or reasoning. Moreover, it's extremely complicated to keep track of the decisions made by such a machine. In fact, the network cannot remember the way the "synaptic weight" values had been updated during its education. Therefore, how can one determine the traceability for a given weight from a given neural input? In practical terms, the more neural layers an artificial neural network (ANN) possesses, the more difficult – if ever possible - is its traceability.

New self-learning techniques – a machine's ability to learn on its own in an unchecked environment by analysing data received on its surroundings and finding solutions to complex problems – will add to the difficulties in following the machine's logic with some precision. Getting back to its capacity of movement, self-learning would amount to the discovery of a new environment and to progressively find the most satisfactory route, moving from one point to another, depending on the established criterion: speed or low energy consumption.

VI. The Dangers of Legal Personality for Military Robots

A robot's legal autonomy would open a second Pandora's Box causing detrimental and far reaching negative consequence on society, just as the original box given by Zeus to a young eponymous woman who opened it despite divine forbiddance, thus bringing all the evils to the world.

From the example given above, it can be admitted that the temptation would be great for a robot's owner or operator to free him/herself from any responsibility in case of problems. If, for instance, it was decided to grant animals legal personality, that are also endowed with feelings, Pitbull owners would then no doubt plead the non-responsibility of their animals' acts, even if they oversee their education and behaviour. In this respect, to quote what has now become a proverb: "Trust is good but Control is better", it can also be said that "delegating power doesn't mean giving up control".

There would, however, be an additional risk of weapons' proliferation using autonomous armed military robots. Belligerents would thereafter be encouraged to use such robots in battlefields, alleging the responsibility to the machine in case of breaches to the laws of armed conflict.

VII. Relevance of the Concept of Autonomy for the Armed Forces

At a time when military resources are scarce [4], the ability of preserving them to fulfil basic tasks is an undeniable opportunity for military leaders. Military robotics provides such capabilities with the possibility of delegating menial but crucial tasks to the machine; for example, mission surveillance and patrolling which drain manpower and are time consuming, or increasing the cognitive load which requires an analysis of large number of images to detect a potential enemy intrusion. This is also the case for 3D (Dull, Dirty and Dangerous) missions, where soldiers can be better protected if machines are exposed to danger in their place.

On the tactical plane, when a combatant is confronted with a sudden threat from the enemy (exposed or under fire), s/he should not have to think about his/her robot. To that end, especially if no instructions have been given to the robots before that critical instant, these machines will need a certain autonomy to avoid thwarting and jeopardizing the operation.

Moreover, a robotic system programmed by the operator for greater autonomy will give him/her greater freedom to concentrate on his/her mission as s/he will not be restrained in controlling the machine. The soldier will thus be much better served by delegating the tasks and/or missions required to these systems and let them execute them without his/her intervention. Naturally, robots with some form of autonomy are needed in this case.

Nonetheless, the use of military robots does not exonerate an operator or a military leader from responsibility. S/he is held accountable for any wrongdoings. It's a constraint having positive effects because it commits a decision-maker to greater prudence when using a machine and prevents him/her from using it in an unsafe manner or contrary to the rules of the law of war.

A military leader provided with a robot must ensure it is incorporated in mission preparations, integrated in its conduct and configured from the first stages onwards. The robot, subjected to follow military rules of engagement, should be programmed all that more strictly as it holds a certain form of artificial autonomy. It will, moreover, be configured following the needs of the mission. However, should a military leader find it unreliable, s/he must remain in-the-loop to resume control at all times.

But if some autonomy may be useful in discharging operators of military robots from dangerous, fastidious or repetitive military tasks on the battlefield, how can artificial autonomy and responsibility be reconciled?

Essentially, any autonomous system must be educated. Just as the owners of animals are responsible for their training and the possible damage they could cause, the military leader will be responsible for the satisfactory training of and the adequate use of the machine in the field. To achieve this, s/he will need to supervise the learning process of the machine before granting it autonomy and then update its programme on a regular basis as well as ensure control over it over time.

VIII. Autonomy and Military Effectiveness

It is stated in Article 1 of the 1933 Regulations on the General Discipline of the French Army that: "As discipline is the main driving force behind the Army, it is therefore important that all Superiors obtain total obedience from their Subordinates". The article in question demonstrates the absolute necessity for a unique command capable of giving orders to subordinates, ensuring a manoeuvre's cohesion and intervening when needed.

A leader gives orders to the units under his/her command. S/he also entrusts them with the execution of the mission they have been assigned; in other words, it's the principle of subsidiarity.

A text of this nature could obviously not be applied to any autonomous system as it has neither human value nor discerning abilities. Nonetheless, if a leader delegates certain missions to the system and leaves it some autonomy to execute them, it means s/he must always be able to take back control from the system to ensure some cohesion in a given military action. This is generally the case for all units s/he may deploy in the field.

Autonomy is thus useful for robotic systems deployed in the field under the condition, however, that they remain executors along with other tactical units, and are subject to orders, counter-orders and reporting requirements.

Accessing very difficult-to-reach environments or in the case of the loss of communications (as in the underwater world where radio wave propagation is weak), certain systems need autonomy to evolve in their respective environments without human supervision. In this case, the operator had previously decided to restrict the system's autonomy for security reasons to a given space for a given period.

As an example, the American Defense Advanced Research Project Agency (DARPA) is currently developing an Unmanned Surface Vehicle (USV) prototype, the Sea Hunter, a surface vessel dedicated to anti-submarine combat. The vessel can operate autonomously for several months, over thousands of miles with no crew on-board whilst respecting international marine navigation rules at the same time.

IX. The Human's Role in Tomorrow's Battles

Regarding the military robot's autonomy in decision-making, there is a risk in trusting the soundness of the conclusions obtained by embedded artificial intelligence. As stated above for neural networks, it seems impossible for an operator using such machines to follow the "intellectual path" of the data the robot processes for decision-making. Accordingly, there are concerns in the inability to assure the accountability of this machine if used on the battlefield. In that case, it would require constant supervision which is contrary to the principle of autonomy.

Therefore, if there is a will of integrating artificial intelligence into our systems without the systematic refusal from the military, be it by sheer defiance or poor conviction, a perfectly transparent traceability function is required by the user and the autonomy of these systems must be controlled by embedded safeguarding software.

Satisfying such conditions will only be possible if the specifications include these constraints right from the design stage and during different learning stages (such as deep learning).

For some systems, embedded safeguarding software should also include ethical and legal constraints in their algorithms and thus benefit from the still hazy labels "Ethics by design" or "Legal by design". In this vein, the IEEE's Global Initiative for Ethical Considerations in Artificial Intelligence and Autonomous Systems prepared a report in December 2016 entitled Ethically aligned design: a Vision for Prioritising Human Wellbeing with Artificial Intelligence and Autonomous Systems [5]. The following statement is an extract from this report: "[…]as AI systems become more capable, unanticipated or unintended behaviour becomes increasingly dangerous, and retrofitting safety into these more generally capable and autonomous AI systems may be difficult. […] We recommend that AI teams working to develop these systems cultivate a safety mindset in the conduct of research in order to identify and pre-empt unintended and unanticipated behaviours in their systems, and work to develop systems which are safe by design."

It can be reminded that the international IEEE Global Initiative also indicates: "a will to address all cultural ethical/moral, religious, corporate and political traditions. It has a leading role for Intercultural Information Ethics [6] practitioners in value-by-design ethics committees informing technologists, policy makers and engineers". In fact, finding a consensual outcome in defining the latter would be a complex matter even before attempting to apply its precepts.

X. Armed Robots

Numerous studies have been conducted at the IEEE Global Initiative for Ethical Considerations in Artificial Intelligence and Autonomous Systems on the effects of autonomous weapons. The major concern generating the most debates and greatest fears - which is also the high point of discussions held at the CCW – relates to LAWS capabilities for autonomous firing decision-making. The author's stance on the subject was made during his presentation of the "Uses of Lethal Autonomous Systems" [7] at the ICMT Conference, held in Brno in 2015. In short, lethal autonomous weapon systems can be an asset for the armed forces in hostile environments (air, sea, underwater, underground or desert environments) or in facing saturating threats or if the advantage of using them is far superior to the danger of an enemy threat developing. The use of such systems should therefore be confined both in terms of time and space with the possibility for the military leader to resume control at all times.

However, to the best of our knowledge, it would be inappropriate for France to deploy LAWS if there are potential or verified risks of causing collateral damage (e.g. in urban environments) even if certain countries consider it practicable in the fight against terrorism.

XI. Is it Ethical to use Robots with Artificial Autonomy?

Raising the question of ethics when operating an autonomous machine amounts to posing a question on the decision of delegating an action to an autonomous system. The autonomy of a robot is in fact quite limited as it has no moral sensibility of its own. The question should hence be posed to a human who carries the responsibility for such machines.

According to Professor Dominique Lambert [8], a military leader can very well use a given system both recklessly and irresponsibly. The opposite would apply in the use of an autonomous system in a responsible and prudent way: (i) if its application is confined in terms of time and space, (ii) if the space in which it evolves has been defined as an acceptable one and, (iii) if all potential behavioural patterns of the machine have been identified and even constrained. Such requirements should ensure the possibility in mastering the accountability of these systems that are potentially able to function without direct and/or constant supervision.

First and foremost, in using a machine, it's the intention of the leader that gives meaning to a military action that will prevail. Depending on circumstances, on threats, on the mission and on the rules of engagement, the leader will decide whether to use the system or not and will bear the consequences of his/her choice.

XII. Conclusions

In the etymological sense of the word, autonomy stems from "auto" meaning oneself and "nomos" signifying law. It would therefore be quite counter-productive for a military leader to let whatever machine make an autonomous decision in a way that allows it to define its own proper law. S/he would then unable to control the manœuvre which, with time, would inevitably lead to jeopardizing the mission caused by a lack of supervision. However, delegating a sort of artificial autonomy to a system, even an armed system, has some sense as it would preserve or protect the human resources under his/her supervision and, would help him/her carry out the mission. Nonetheless, s/he must bear overall responsibility for the machine because the artificial autonomy of a machine cannot exonerate the person using it from its duties.

It can also be agreed that the concept of granting legal personality to robots would not be a good idea. It could even have the perverse effect of causing the proliferation of such machines. Besides, it has no sense with machines of this type as they can be duplicated indefinitely, which would cause legal accountability duplication ad infinitum. And what can be said for a robot reclaimed from the enemy on the battlefield? Can it be treated as a prisoner of war if it has rights due its legal personality?

Faced with the challenge posed by military robotics that is profoundly changing traditional military practices and modes of action and, to give any sense to combat engagement and to the use of lethal weapons, future combats should rely on the leader, an officer trained to take decisions. In this vein, it's worth citing General Michel Yakovleff who stated, in 2011 at the Ecoles de Saint-Cyr Coëtquidan, that: "If future wars may be robotised, it's not a future dreamed by humanity".

Acknowledgment

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