LAWS: LATENT DEMAND FOR SIMULATION OF LETHAL AUTONOMOUS WEAPON SYSTEMS

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Abstract

This paper provides an overview on the Lethal Autonomous Systems (LAWs) and related critical issues caused by dynamically evolving context. Traditional approaches to evaluate new system development, software review, prototyping and testing are often not really efficient or even not applicable in this LAWs even due to the evolution in terms of social and operational scenarios. Vice versa, it is evident that simulation plays the key role to support evaluation of scenarios considering that is practically the only methodology able to develop and to conduct virtual tests on concepts, general principia, strategic decisions, technology impacts and related implications.

1. Introduction

The evolution of technology allowed us to experience a new world where autonomous vehicles, intelligent and robotic systems are a dynamically evolving reality; it is currently over a decade since such solutions have been used in operations in theaters (e.g. peacekeeping, peace enforcement, war, etc.), however, their current technological capabilities and quick evolving advances in this field make it very hard to define the boundaries of operational use and their future developments. Discussions about the impact of these systems are ongoing and have been for several years, therefore the authors in this paper propose some kind of wrap up of very consolidated concepts and an overview on the way ahead by defining M&S (Modeling and Simulation) as the key technology to be used as reference guideline.

The use of lethal force by Autonomous Systems is always twofold considering that for someone the autonomous systems are not very different from any other weapon while for others these have to be considered as new kinds of weapons based on "applicative" artificial intelligence. Indeed, many people consider responsibility of the

human component to "use" or "activate" autonomous systems; however sometime, it could seem that autonomous systems resemble to intelligent weapons that, in "some way", "self-direct" on the foe targets. Other people further stress the LAWS context by adopting a different point of view; they suggest that a robotic system could be considered not really different from a simple assault gun that shots bullets against enemies as soon as the trigger is activated by a soldier; the point is that obviously an autonomous intelligent system, contrary to an Automated Guided Missile (AGM), or even to a rifle, could have degrees of freedom in how to proceed based on his situation awareness and boundary conditions. In facts, even just to execute and order of direct fire on target, an UMS (Unmanned Systems), when remotely operated from far away, needs autonomy in executing orders just to guarantee an effective real-time control respect to communication latency and constraints. So, it is evident that such systems could, from a technological standpoint, already deal with engaging a target while patrolling or carrying out other tasks introducing some kind of robotic "weird free will".

2. Capabilities And Priorities

The new computational and operational capabilities of robotics systems introduce the main issue on this topic: it is evident that the word "autonomy" represents the crucial element of this equation and the problem is not limited only to liability for acts during operations, but involve many more considerations; therefore there is a way to address these issues and it deals with using simulation to create an independent validation and verification framework to check compliance of the UMS with RoE (Rules of Engagement), laws of war, international humanitarian law, etc.

These new capabilities of UMS are the major reasons why the new UAV (Unmanned Aerial Vehicle), thanks to their advanced technology supporting autonomy, are able to achieve valuable results almost impossible for the original generations of RPV (Remotely Piloted Vehicle) planned to be used in operations, half a century ago (e.g. AQM-34V). Therefore there are still limits; for instance it is quite a while from the first very positive results on tests where a RPV interceptor engaged in dog-fight against an highly experienced pilot on a F-4 (Larm 1996), however even today the use of UAV in these roles is still limited.

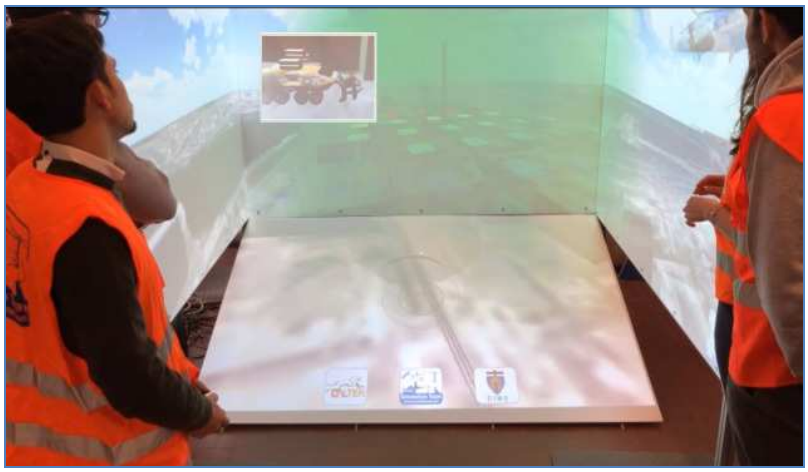

Figure 1. Supervision of UMS in CBRN Scenario

In facts, it has taken close to a decade from appearance of the new generations of UAV since their first operational use; in facts during first years of third millennium we record first cases of lethal force use by autonomous systems are recorded in combat over Asia, but we had to wait another decade to observe first UAV-to-UAV refueling between two Global Hawks of NASA (Gipson, 2016).

This basic observation of existing situation makes the priorities clear, but also it outlines what it is the general trend in this sector and suggests that humans should address these issues as soon as possible and in proper way; simulation is the way to create virtual worlds where it is possible to investigate these elements and to evaluate alternatives and potential solutions (Bruzzone 2016).

Figure 1 proposes an example where the immersive interactive interoperable SPIDER (Simulation Practical Immersive Dynamic Environment for Reengineering) by SimulationTeam is used to supervise and review joint operations involving different UAV and UGV (i.e. fixed wing and rotary wing) in a CBRN Scenario, getting full understanding of the implications of different directions, RoE and policies (Bruzzone et al.2016a). Lethal force assigned to autonomous systems often introduces serious legal, ethical and practical issues that turn to be even more crucial challenges in relations to new generations of UMS such as UAV, UGV (Unmanned Ground Vehicle), USV (Unmanned Surface Vehicle), UUV (Unmanned Underwater Vehicle) or AUV (Autonomous Underwater Vehicle).

3. Evaluation & Development of LAWs

The evaluation and the development of Lethal Autonomous Weapons Systems (LAWs) affect all actors in conflict. LAWs generate a paradigm shift and not a simple

evolution of existing weapon systems with limited impact within well defined perimeters. These toys play by themselves and simulation can be offered to developers, evaluators, opponents because the battle for and against LAWs has already started in several theatres. Legal development, political communications and technologies could be soon based on simulation more than on experience. Therefore, the market for simulation of autonomous systems, lethal or not, includes system developers, political communicators, legislators, lawyers, military and civilian trainers and last but not least gamers and new, interdisciplinary teams that have yet to be established.

"An autonomous system is capable of understanding higher-level intent and direction. From this understanding and its perception of its environment, such a system is able to take appropriate action to bring about a desired state. It is capable of deciding a course of action, from a number of alternatives, without depending on human oversight and control, although these may still be present. Although the overall activity of an autonomous unmanned aircraft will be predictable, individual actions may not be." (Ministry of Defence, 2017)

4. Leaving nothing to chance

The decision-making process separates automatic from autonomous weapons. Indeed, decision making is a cognitive process and not a mechanical one while the choice is based on alternatives that have to be evaluated according to values and preferences. The process requires much more than engineering as ontological and epistemological issues that govern decision making process. The complexity of such processes was addressed in the early 90s in Artificial Morality - Virtual Robots for Virtual Games (Danielson, 1992) in which the author uses PROLOG to write simple decision-making programs.

Laws of War and Rules of Engagement define the principles of conduct and in engineering terms constitute higher and intermediate constrains, from an epistemological point of view they constitute the ethical or moral boundaries. Danielson combines morality with game theory to develop intelligent agents. "The constructive resources of artificial intelligence allow us to build most of the desired agents and manage the complexities that result from their interactions" (Danielson, 1992).

Last, and most interesting, is the realisation that less constrained behaviour frameworks or simple maximisation ("SM") strategies underperform and might never outperform constrained maximisation ("CM") whose pursuit of simple self-interest can harm overall performance.

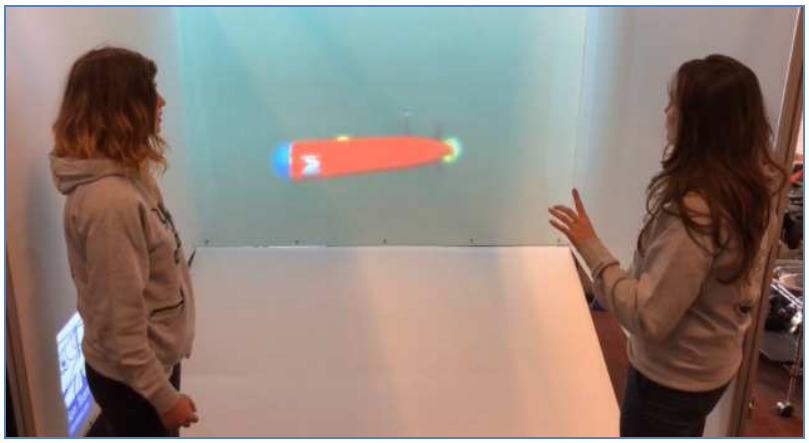

Figure 2. Criteria Analysis for AUV in Virtual World

The use of the word morality evokes images and reactions from both civilian and military minds that are often unhelpful in this context. The reader is best served by accepting moral theory as rational choice theory .

In much of the academic literature on the subject of LAWs the problem posed by Isaac Asimov emerges defensively, apologetically for fear of quoting an icon of popular culture. Asimov, a scientist and academic and a military man himself, coined the term robotics . In his writings he illustrates the difficulty robots encounter when applying the laws. Other attempts to define rules that should define a robots' cognitive processes include those of the Engineering and Physical Research Council and the Arts and Humanities Research Council of Great Britain (https://epsrc.ukri.org). Sadya Nadella provided six basic rules of AI in an article in Slate magazine (Nadella, 2016) later reviewed in The Verge (Vincent, 29)

There is currently a communication battle on media where opposition to killer robots creates headlines, legal issues arising from the use of any UMS. These elements are pretty complex it is almost impossible to evaluate risks and consequences without using simulation. In near future we will see this to be further extended to advanced technological developments of AI that could represent major opportunities or risks; in facts these considerations could evolve on media being viewed in emotionally charged terms.

5. A list of problems/opportunities to offer simulation as a tool

The opportunity for the development of simulation starts with testing the hypotheses on the mission environment and conditions related to use of LAWs. As testing these devices incurs significant cost and risk layering simulation ahead of battlefield testing makes a lot of sense. You can test a tank in a range and just stand

back... not so with many LAW systems. The contexts need to address multiple different issues that requires to be properly considered (Scharre 2014) as in www.cnas.org/publications /reports/robotics-on-the-battlefield-part-ii-the-coming-swarm.

Cognitive issues
(a) Discriminating between different agents.
(b) Deciding how to behave with the different agents
(c) Self-interest of the robots vs humans
(d) Conflict of interest and conflict of preference.
(e) The decision of which agents have to be treated morally and which ones should not.

Technical issues
(a) Incomplete information
(b) Unexpected accelerated pace of interactions
(c) Unexpected interactions between adversarial systems
(d) Spoofing
(e) Behavioural hacking
(f) Technical hacking

Risk
(a) Strategic Mission Failure
(b) Tactical Mission Failure
(c) Failure to Respect Rules of Engagement and Laws ow War
(d) Civilian casualties
(e) Fratricide
(f) Unintended escalation

6. Modelling situations as games

The analytical reasoning process could be analysed using tools such as logic programming languages such as Prolog, ASP and Datalog in which clauses represent rules: these were developed initially in the 30s and have allowed for the interaction of the skillsets of logicians, psychologists, ethicists, lawyers with the experience of operational military personnel.

Logic games provide the first testing ground for LAWs. Simple ones include Prisoner's dilemma, involving parameters such as fitness, egoism and utility; this evolves into the Iterated Prisoner's dilemma to add a level of complexity. Tit for tat, with its simple logic, but still requiring an evaluation of the symmetry of action and effect. Far more complex is the decision mechanism in the Chicken game, and so on.

The development of games starts by addressing basic challenges such as maximisation of interest, determining the optimal level of constraints on self-interests. Also, the level of cooperation between agents and what conditions should be imposed on it.

Testing the potential for endless loops given the logic. There is a long list, but the question that manufacturers will have to address is how they can act responsibly to the extent that limits their liability. Will the manufacturers expose the weaknesses in the internal logic of LAWs and in the interaction with other agents early enough to do something about it or will we have problems?

7. Major Challenges & Opportunities

"Strategic agents consider all alternatives and consider what the other agent can be expected to do in response to each of them", "That is what distinguishes sophisticated strategic thinking... from the simpler parametric situation of an agent" (Danielson, 1992).

The intelligent agent, or agents, in a LAWs have to be able to constrain their actions for the sake of benefits shared by others. Due to these reasons the authors suggest the adoption of advanced solutions inspired by the IA-CGF created by SimulationTeam (Bruzzone 2013, 2016; Bruzzone et al.2014). The Intelligent Agent Computer Generated Force have evolved along two decades and show ability to address complex scenarios in disaster relief (Bruzzone et al.2016b), hybrid warfare (Bruzzone et al.2017b), cyber warfare (Bruzzone et al.2013) and protection of critical infrastructure (Bruzzone et al.2016a) with very interesting results and experimentations (www.liophant.org/projects). Indeed this necessity is over stressed when multiple autonomous systems interoperate as happen in JESSI Scenarios (Joint Environment for Serious Games and Simulation Interoperability) including UUV, USV, AUV and traditional assets; figure 2 illustrates the review of operations by a AUV that due to its nature (very limited communication capabilities) representing the most evident necessity to define criteria for operating autonomously in Joint Naval Operations (Bruzzone 2016); another case is proposed by T-REX simulator in Figure 3 related to a swarm attack by micro UAV on a critical infrastructure simulated jointly with cyber-attacks. In addition, a very interesting aspect is related to the dual use of these techniques for both military and civilian Applications (Bruzzone et al.2017a).

8. The state of the argument

United Nations and this Subject

Current discussions on conventions are taking place in Geneva on an annual basis within the framework created by the UN within the High Contracting Parties to the Convention on Prohibitions or Restrictions on the Use of Certain Conventional Weapons Which May be Deemed to be Excessively Injurious or to Have Indiscriminate Effects (CCW)... one could not try to make a more obscure name or setting as if to hide a debate rather than bring it to the forefront of attention. However, the list of participants is endless including governments, human rights organizations other NGOs and prominent individuals including International Committee for Robot Arms Control, Human Rights Watch, Seguridad Humana en Latino América y el Caribe and the Campaign to Stop Killer Robots Need for meaningful human control. (United Nations Office at Geneva, 2018)

Arguments against LAWS

a. that the use of AWS is either per se unethical or less moral than the use of currently available technology because of the exclusion of the human form specific decision processes dehumanise the target and the attacking side; and

b. that the decision-making process of AWS cannot currently match the ability of humans to respect the rules of engagement based on the Law of War and International Humanitarian Law and, according to some commentators but not all, that it is impossible for AWS (i.e. computers) to apply the rules of engagement set within the framework of the Laws of War and International Humanitarian Law, as well as a human being, would.

c. Hitherto, weapon technology has relied on the control exercised by humans in the loop, yet it allowed for the very existence of humanity has been threatened by errors that came close to causing nuclear war. Close Calls with Nuclear Weapons and the increasing reliance on autonomous systems may be viewed as irresponsible and unethical until such a time when it can be proved that AWS can be relied upon to act within the framework provided by the Rules of Engagement, based on the Laws of War and International Humanitarian Law

Arguments supporting the development and deployment of LAWs

a. that the exclusion of human in the loop will reduce errors and violation of the rules of engagement due to mistakes or deliberate actions of insubordinate personnel, thereby producing a less dangerous conflict; and

b. that the reduction of the number of exposed military personnel and the more surgical and precise nature of military strike action will reduce civilian casualties, thereby making was less destructive.

Legal Arguments

The legal argument is a Pandora's Box in its own right. Criminal law requires the assignation of responsibility to a person or entity that has the moral agency to accept responsibility for a crime. If this is the case, there seems to be no solution for the

responsibility gap if we accept this gap in our day-to-day lives. For example, when driving a car, we cannot predict with certainty the conditions of an entire road. The smallest anomaly, like a small shard of glass, can cause a tire to burst and a fatal collision to occur.

The driver cannot be held responsible for any death as he was not responsible for placing the shard of glass. The manufacturer who built the car with the highest standard of 'due care' cannot be held responsible because the car itself was not at fault. Finally, the workers who paved the road cannot be accountable as we could never know for sure when the shard of glass was introduced. The collision would be deemed an accident. We seem to have much higher standards when war is concerned, and a responsibility gap that allows for accidents and lack of responsibility seems unacceptable when it comes to taking a human life. If an AWS can be causally responsible for deaths seen in a war but cannot be legally and morally responsibility, then arguably the war in question is not a Just War nor a humanitarian one. It appears that for the time being, responsibility for the actions of AWS will remain with a human controller, until such a time when a fully autonomous system will possess the appropriate level and kind of autonomy to assume full legal and moral responsibility for its actions. (Gocek, 2018)

9. Stimulating quotes

It is evident that this problem is pretty extended, and this paper proposes just elements to be considered, therefore the identification of Simulation as approach to address these issues is an important step forward. Indeed, the following quotes are proposed to stimulate discussion and to facilitate the summarizing of final conclusions:

"if we continue to develop our technology without wisdom or prudence, our servant may prove to be our executioner". (Gen. Omar Bradley)

"The only theoretical reason to take artificial intelligence more seriously than clockwork is the powerful suggestion that our minds work on computational principles" (Haugeland, 1987)

"the AI arms race is propelled by unstoppable forces: geopolitical competition, science pushing at the frontiers of knowledge, and profit-seeking technology businesses. So the question is whether and how some of its more disturbing aspects can be constrained. At its simplest, most people are appalled by the idea of thinking machines being allowed to make their own choices about killing human beings. And although the ultimate nightmare of a robot uprising in which machines take a genocidal dislike to the human race is still science fiction, other fears have substance" (The Economist, 2015)

10. Conclusions

Digital simulations are already used to train, teach and evaluate soldiers in a range of operations from cultural interactions to language skills to weapons training and even the treatment of PTSD (Mead, 2013), but these simulations follow a relatively narrow set of parameters and the cost of any mistakes is limited.

The use Lethal Autonomous Weapons Systems (LAWS) poses serious legal, ethical and practical issues.

Precedent or convention do not yet define the liability for illegal acts resulting from the operation of LAWS in spite of the efforts of the United Nations Office for Disarmament Affairs. In the absence of an international convention, users and manufacturers will try to assign responsibility to each other. The only way both parties can reduce the burden of responsibility is by introducing independent verification of the compliance of the systems with the rules of engagement, with the laws of war and with the international humanitarian law.

An analytical approach involving the review of code and engineering specifications is neither practical nor likely to be effective. Hence, simulation is the only empirical approach that users and manufacturers of LAWS can employ to counter accusations of negligence and criminal lack of regard for the respect of codes of military conduct. The use of simulation will require exposure of the weaknesses and errors in the logic embedded in systems which may not be readily accepted by the supplier.

The need to match the enemy's use of LAWS and the power of the arms manufacturers may put pressure on governments to accept minimal standards of verification of the compliance of systems with rules of engagement and other legal requirements.

The emotional and political impact of the advent of the "killer robot" will contrast the cost/benefit analysis implied by calculating the number of violations of laws and rules of engagement due to human activity vs deployment of systems.

The requirement for simulation will probably emanate from the following:

1. Manufacturers of LAWs and or anti-LAW systems
2. Political communicators wishing to attack or defend the use of LAWs
3. Legislators who wish to evaluate cost/benefit and risk/reward profiles.
4. Lawyers who are attempting to establish or reject liability for the use of a system
5. Game development companies in both training and recreational markets.

Figure 3. Simulating Swarm attack of Suicide UAV

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