

The Use of AI and Robotics in Armed Conflicts

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Abstract. This systematic literature review (SLR) explores existing and newly emergent ethical and legal challenges associated with the use of AI and robotics in armed conflicts. We conducted an extensive review of relevant scholarly publications associated with (lethal) autonomous weapons systems (LAWS). Besides the ethical and legal principles, we also explore emergent technical applications associated with these technologies in armed conflict(s). Our particular focus is to compare literature from the last 12 years with publications since the outbreaks of recent armed conflicts from the perspective of LAWS. We engage in exploring and identifying the shifts in ethical arguments and discourse, as well as shifts in policy subject themes, and standards setting around the use of emergent technology in relation with AI and robotics. Our contribution analyses emergent socio-technical themes and arguments relevant for engineers, policy-makers, and other interdisciplinary scholars across a variety of disciplines.

Keywords. transdisciplinary engineering, autonomous weapons, robots, AI, ethics

Introduction

The US Department of Defense (DoD) defines AWS as weapon systems, which can engage targets without further human input by its operator, after the system activation [1]. Autonomous weapon systems (AWS) is a challenging ethical, legal, social, as well as engineering technology. Their lethal version, lethal autonomous weapon systems (LAWS) are entering the current battlefields, while the conceptualization of these technologies is with us for the past decade. This systematic literature review (SLR) explores existing and newly emergent ethical and legal challenges associated with the use of AI and robotics in armed conflicts. We asked the following questions:

1. What are ethical issues associated with the use of AI and Robotics in armed conflicts?
2. What are technical applications associated with the use of AI and Robotics in armed conflicts?
3. What are legal principles associated with the use of AI and Robotics in armed conflicts?
4. Is there any noticeable shift in the scientific discourse (and potential policies) about the use of AI and Robotics following the wars in Ukraine and Gaza?

1. Methodology

Our systematic literature review included four steps. First, we developed a set of keywords as search terms for interrogating the scientific databases, as follows:

((“artificial intelligence” OR AI OR robot OR robots OR robotics OR “machine learning” OR “deep learning”) AND (“armed conflicts” OR “armed conflict” OR wars OR war OR “autonomous weapons” OR “autonomous weapon”))

The search string comprised 2 domains: technology-related syntax (i.e., AI/machine/deep learning and robots); and armed conflicts- and war-related syntax (alongside autonomous weapons systems). The syntaxes were refined through multiple iterations and test-searches in the selected databases. Secondly, we queried the selected scientific databases with the combined syntax. The the test searches and the data sources were collected in the following selected scientific databases: Scopus, Web of Science, HeinOnline. We selected a variety of databases to minimize the noise and optimize the relevance of the results. The searched databases excluded Google Scholar for reasons of questionable reproducibility of the search results [2]. Minimal changes to the query were made, wherever needed, to reflect the database-specific syntax requirements.

Thirdly, we also defined our selection criteria of the relevant publications, as follows: 1) the articles need to be published in the last 12 years, i.e., between 2012–2022. The reason behind selecting the year 2012 as a starting date for the database query was that this was the time when scholarly communities worldwide started to analyse the topic intensively; 2) the articles’ title, abstract needed to be relevant to the research questions; 3) the articles must be published in peer-reviewed journals or conference proceedings; 4) the full-text must be written in English. During the conduct of the literature analysis two wars occurred (Ukraine and Gaza). Hence, we further extended the end-date of the query to Feb 2024. Consequently, we also added a 4th question to the existing list of research questions.

Fourthly, the resulting list of publications from the database queries were exported into a reference manager, where they were analysed for duplicity with any duplicates eliminated. The titles and abstracts of the papers were assessed for relevance.

The evaluation of the retrieved publications from the database search, following the syntax query containing the relevant search terms, was based on the Preferred Reporting Items for Systematic reviews and Meta-Analyses (PRISMA 2020) methodology [3], applied for new systematic reviews.

Fourth, the resulting list of relevant publications were analysed by all 4 authors (AM, ET, PN, and CI), following qualitative analysis by reading and annotating the full-text of the articles (Fig. 1). The qualitative analysis of the results and their ethical relevance has been inspired by Mepham’s methodology (a practical framework to guide ethical analysis and discussion) of ethical analysis [4], with the help of an ethical/legal matrix adjusted to the needs of this literature review.

2. Results

The search yielded in total 162 articles, from which 70 were reachable to the researchers from library and database subscriptions from their institutions from the search #1 (2012–2022), and 44 respectively from search #2 (2022–2024).

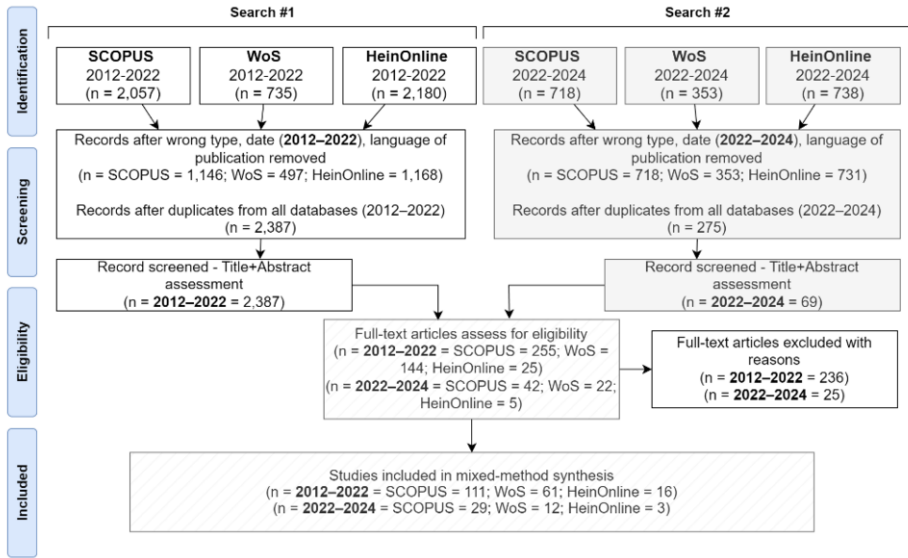


Figure 1. PRISMA 2020 [3] Flow Chart.

Fig. 2 demonstrates that recent publications focus less on social and technology-related issues, while there is a slight increase in ethical and legal analyses.

From the search #1 (2012–2022) 22 papers (31.4%) mentioned recent wars: either

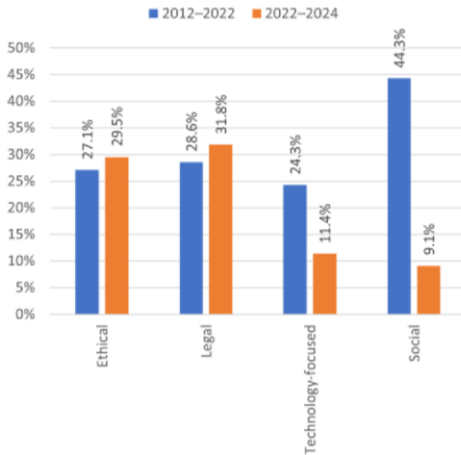


Figure 2. Overview of publications based on domain-focus.

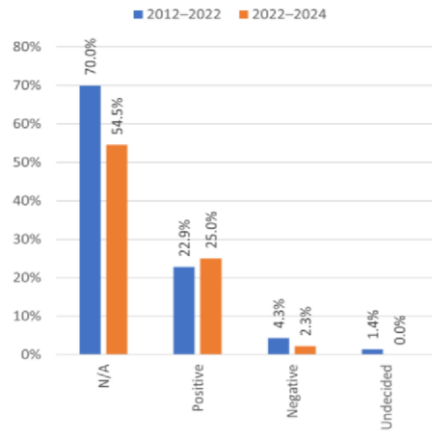


Figure 3. Proportion of attitudes towards the 'Stop Killer Robots' Campaign.

wars in Afghanistan (2001–2021) or Iraq-Second Persian Gulf War (2003–2011). Only a single paper [5] mentions the conflict in Ukraine from 2014 onwards. From search #2 (2022-2024), despite the full-fledged war in Ukraine and Gaza, only 8 papers mention the Russo-Ukrainian War (2014– with further escalation in 2022–), and only 7 mention Israel-Hamas War (2023–) specifically or indirectly as another recent war in the Middle-East [6–15].

A common sentiment amongst the papers analysed before the start of the Russo-Ukrainian war in 2022 (i.e., search #1) is that while AWS may exist in the form of Close-

in Weapons Systems (e.g., the Phalanx or Goalkeeper), however, LAWS simply do not exist yet (the latest paper analysed in this literature review that mentioned LAWS not existing was published in 2021 [16]). The papers published after the start of the Russo-Ukrainian War specify as early as 2016 that LAWS are being used in the form of Loitering Munitions, which refer to weapons launched by a human operator, which subsequently find their target fully autonomously [6].

The main focus of the predominantly *legal* publications between 2012–2022 concerned the International Humanitarian Law (IHL) [17], in particular how LAWS can infringe upon IHL's definition of proportionality [17]; targeting rules [17, 18]; collateral damage [17]; responsibility gap between (L)AWS and the operators and commanders [19]; human rights consequences of autonomous weapon systems [16], *International Committee of the Red Cross* [16]; and the '*Stop Killer Robots*' campaign [20].

The '*Stop Killer Robots*' Campaign was first launched in 2013, and has since been used as a point of departure for many publications [20]. It is often cited as a campaign that initiated the debate about LAWS [20], urging governments and the United Nations (UN) to issue policies, which would outlaw the development of LAWS. Fig. 3 summarizes the attitudes of the authors towards this campaign, whereas 22.9% (2012–2022) and 25% (2022–2024) reflect on this campaign with a positive attitude, and 4.3% (2012–2022) and 2.3% (2022–2024) with negative attitudes. The majority of publications (70% from 2012–2022; 54.5% from 2022–2024) do not pick any stance towards the Campaign.

Publications from 2022–2024 in the legal domain also focused on International Humanitarian Law (IHL); distinction (provides that parties to an armed conflict must at all times differentiate between the civilian population and combatants and between civilian and military objectives and that conflict must only be directed towards military objectives) [21]; military necessity permits measures to be taken to accomplish a legitimate military purpose and are not otherwise prohibited by international humanitarian law [9], humanity and precaution (humanity requires that those who have fallen into enemy hands be treated humanly at all times, seeking to limit suffering, destruction and injury during armed conflicts. Precaution refers to taking constant care to spare the civilian population, civilians and civilian objectives and in any event to minimize the incidental loss of civilian life, possible injury to civilians and damage to civilian objects [9]. Authors such as [22] believes that the current form of IHL is insufficient, due to recent advancements of AI widening the responsibility gap, especially when inevitably things go wrong [19].

The publications from 2012–2022 focusing on *social* aspects of autonomous weapons systems focused on the subjects of drone warfare [23]; just war theory [24], governance [25], autonomous weapons [20]; the UN *Convention on Certain Conventional Weapons* (CCW) [20]. Scholarly literature from 2022–2024 within the social domain focuses on the public debate about the weapons autonomy [26]; the effects of drone warfare on the civilian population [7], moral responsibility for AI based outcomes [19]; position of different countries on the development of LAWS [27].

Publications from 2012–2022 with predominantly *ethical* viewpoints focused on Human-Robot Interactions [25]; Ethical Design [25]; ethical complexities of war [28], namely, whether delegating life and death decisions to machines inherently undermines human dignity [28]. Publications from 2022–24 with ethical perspectives focus primarily on ethical frameworks development, which would assist in tackling challenges raised by AWS and LAWS (e.g., human dignity, target identification [29]; public attitudes towards

different degrees of weapon autonomy and how this affects public approval [26]). Others focus on topics of just war traditions and military ethics [8]

Finally, the predominantly *technology-focused* publications from 2012–2022 investigated country-specific strategies for AI [30]; responsibility towards the use of AI [25]; swarming technology [23]; target selection [31], operational scenarios on how LAWS can be used by armed forces addressing operational benefits and ethical issues[32].

The technical debate between 2022–2024 focuses on the different categories of AWS and LAWS, and particularly on the question what constitutes their definition [15]. Others are concerned about the opportunities and risks of using LAWS, and discuss the connection between the ethical, legal, and social aspects of such weapon systems [33]. Furthermore, non-state actors’ access and use of LAWS technologies has been investigated by Kwik [34].

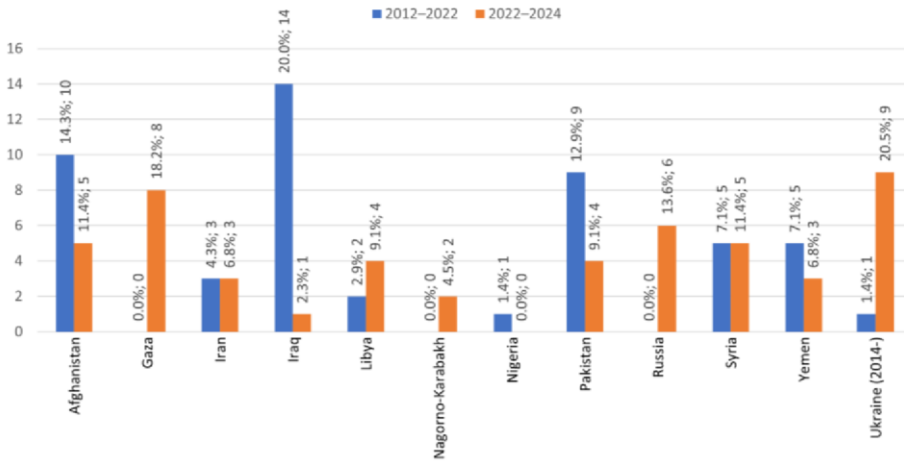


Figure 4. Conflict mentions breakdown in scholarly literature discussing LAWS.

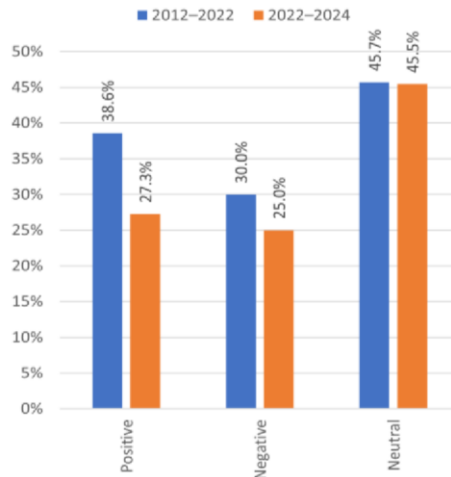


Figure 5. Proportion of attitudes towards AWS/LAWS in the scholarly literature.

In summary, many of the topics of ethical, legal, and social relevance identified in the scholarly literature before 2022 (search #1) returned also in the publications following

2022 (search #2). The only noticeable difference is that the technical debate is less focused on hypothetical scenarios, and is dominated by the current operations of AWS, while investigating what stance societies should pick in relation to currently existing and used technologies. Moreover, Fig. 4 confirms the shift in mentions in the reviewed articles from wars in Afghanistan and Iraq between 2012–2022 to more recent wars in Ukraine and Gaza between 2022–2024. Fig 5. indicates no significant shift in the proportion of overall attitudes towards AWS/LAWS in the reviewed scholarly literature.

3. Findings

3.1 *Legal Principles Associated with the Use of AI and Robotics in Armed Conflicts*

During the use of LAWS in warfare one is bound to International Humanitarian Law [18], which defines a set of standards that seek to limit the effects of armed conflicts [18]. These standards are:

- *proportionality* — defined as “requir[ing] a military commander to cancel or postpone an attack which may be expected to cause incidental loss of civilian life, injury to civilians, damage to civilian object or a combination thereof, which would be excessive in relation to the concrete and direct military advantage anticipated” [17]
- *distinction* — requires that parties to an armed conflict must at all times differentiate between the civilian population and combatants, and between purely military and civilian objectives; and ensures that conflict must only be directed towards military objectives [21]
- *military necessity* — permits measures to be taken to accomplish a legitimate military purpose, and are not otherwise prohibited by IHL [9]
- *humanity and precaution* — the former requires that those who have fallen into enemy hands should be treated humanely at all times, seeking to limit suffering, destruction and injury during armed conflicts. The latter refers to taking constant care to spare the civilian population as well as civilian objectives, and in events where civilian casualties are not possible to avoid, to minimize the incidental loss of civilian life, possible injury os civilians, and damage to civilian objects [9]

On the other hand, Sehrawat [22] concludes that the current form of IHL [18] is insufficient for incorporating LAWS due to recent advancements in AI, which contributes to the widening of the ‘responsibility gap’ [19]. We will describe the problem of responsibility gap in a later section.

While the main focus of most articles is IHL [18], we also find mentions of Rules of Engagement (ROE) [35] and International Criminal Law [36].

3.2 *Technical-Engineering Design Challenges Associated with the Use of AI and Robotics In Armed Conflicts*

The main technical challenge surrounding the use of AI on the battlefield is related to the idea of humans in-/on-/out-of-the-loop [37].

Human-in-the-loop means that LAWS are not fully autonomous regarding its lethality and still requires a human operator to agree with the decision to select a target. In this scenario, a robot still uses human-defined criteria to select targets and to calculate

proportionality. A human must press a button to confirm the kill decision after which the robot engages [37].

Human-on-the-loop means that LAWS can kill a human without a finger on the trigger by a human operator. In this case, a human operator has the opportunity to abort the kill decision or override the robots target selection. In this type of architecture, it is presumed that if a human does nothing within a set time limit after target selection then the target will be engaged [37].

Human-off-the-loop/out-of-the-loop means that robots or LAWS take the human-defined targeting criteria and engage in its mission. There is no more finger on the trigger by a human operator and once launched the weapon will find its way towards the target [37].

In addition, this technical challenge also encompasses the types of algorithms and machine learning (ML) used to train LAWS [29]. We have seen from large language models that they require massive amount of data to train to even come close to writing and speaking like a human. Analogously, training LAWS require the same or even more data to facilitate sufficient decision-making support (or autonomy) to responsibly harm an enemy combatant. These datasets will need to be acquired or generated, while IHL [18] and other regulations like ICL worldwide try to limit the amount of possible wars. The contradictory nature of LAWS is that while some (aggressive or militant) countries might be motivated to acquire sufficient amounts of combat-related data to train their LAWS, peace-seeking countries alongside international laws might fall short of such training data for their defense systems, making the latter countries increasingly vulnerable [29]. To be able to do this one has to set the right parameters to gather the data in combat situations and then be able to analyse this data and use it to develop a model. This form of data gathering creates ethical problems and may be difficult from a technical perspective.

3.3 Ethical Issues Associated with the Use of AI and Robotics In Armed Conflicts

Multiple ethical considerations are mentioned in the reviewed literature on LAWS, namely, public attitudes towards different degrees of weapon autonomy and how this affects public approval [26]); human dignity in target identification [29]; the ethical complexities of war [28]; in particular, whether delegating life and death decisions to machines inherently undermines human dignity [28]. We elaborate these further in the following sections.

3.3.1 Public Attitudes towards LAWS

Discussions about LAWS are not confined only to academic and governmental circles, but often take place in the public domain, including NGOs and civil-society organisations (CSOs), for example the ‘Stop Killer Robots’ initiative. While academics are mostly concerned with the ‘responsibility gap’ of LAWS, the public is increasingly concerned about the targets chosen by the military, and the collateral damage or civilian casualties caused [26].

The worries of scholars about the ‘responsibility gap’ refers to delegation of the responsibility of lethal decision-making to machines, and in particular, how fundamentally unethical it is as it violates the right to human life and human dignity. For example, it would be almost impossible to assign responsibility to malfunctioning LAWS

or war crimes committed by LAWS, and therefore the term ‘responsibility gap’ refers to the gap for the possibility of prosecution [19].

Although the concept of responsibility gaps is disputed, three different opinions can be found in the scholarly literature about them [19]: *a)* some argue in favour of their existence ; while others object against their existence [19]; *b)* some highlight that ‘responsibility gaps’ constitute a new moral problem; while others argue, they do not [19]; and finally, *c)* some believe that solutions can be found for the resolution of ‘responsibility gaps’; while other do not share this opinion [19].

The public debate is predominantly focused on the targets of military strikes, and whether there are any collateral damages or civilian casualties [26]. Rosendorf et al. [26] investigate how increasing weapon autonomy affects the approval of military strikes resulting in collateral damage, the perception of their ethical nature and blame-attribution for civilian casualties. This is done through a survey on a sample of 1,006 US citizens. The results highlight that as the autonomy of weapons increases, public approval and the ethicality of military strikes with collateral damage decreases [26]. Increasing the autonomy of weapons is associated with greater blame for civilian fatalities only towards the machine(s), the manufacturer, and the software developer, while the amount of blame towards the operator and the commanding officer remained constant [26]. The overall results show that humans, rather than machines, remain the most blamed entities, irrespective of their degree of autonomy [26].

3.3.2 Target Identification

Recent scholarly debate also investigated whether LAWS can fully execute a kill-chain of actions (i.e., from target identification to lethal action), and what its impacts are on human dignity. The main ethical question can be summarised by asking whether a robot can correctly distinguish between civilians (e.g., children) alongside friendly forces, and enemy combatants, who can be ready to fire, or willing to surrender [24]. The training of an ML-model to analyse such a complex situation needs large amount of training data showing both enemy forces, civilians, and friendly forces in real-time (chaotic) combat situations. Part of this training data could be generated by war games and exercises, but without real combat data this would leave a gap (i.e., Rules of Engagement), which could prove problematic in future real life scenarios [29].

Concerning human dignity, some authors [28] fear that allowing a machine to complete the kill-chain may lead to ‘de-humanization’ in decision making. “A machine does not consider the death of civilians as collateral damage or take into account the morality of annihilating the life of an enemy combatant, even when they have indicated their surrender” [29].

3.3.3 Ethical Complexities of War

The preceding discussions on ‘responsibility gaps’ and ‘targeting’ underscore the challenges inherent in the deployment of LAWS. These complexities are further exacerbated in situations where, for instance, civilians may carry items resembling (from the perspective of military operators) weapons; or where civilians, including minors, blur the lines between military and civilian domains through activities such as reporting.

Although all human life is inherently valuable, some contend that permitting machines to autonomously select and engage targets infringes upon fundamental human dignity, as individuals possess the right to be killed by a human who has consciously made that decision [28]. Ethically speaking, a degree of dehumanisation always remains

either by complementing decision with human-in-the-loop; while the human-out-the-loop decisions further aggravate the dehumanisation of the affected individuals. Horowitz [28] argues that automating the process of killing is by definition unethical and may create a ‘vacuum of moral responsibility.’ In his view machines are not moral actors, and also cannot show compassion and intuition, as these are human attributes [28].

On the other hand, opponents argue that everyone who enters the military force must fully understand the risks, which may involve the possibility of being killed in action. The how does not make a difference once one is dead. From the purely consequentialist perspective there is little difference between a death caused by an unguided bomb, or death in close-quarter combat by a soldier or an insurgent. While the human dignity argument has an symbolic, emotional, and ethical resonance, it may also romanticize warfare [28]. Ethical complexities were always present in wars, however, it is important to define explicitly what (L)AWS are allowed and not allowed to do in war.

4. Conclusion

Preceding the wars in Ukraine and Gaza (search #1, 2012–2022) most of the reviewed literature focused on (mostly) hypothetical use of LAWS. These papers emphasised the ethical implications of LAWS on civilians and enemy combatants (e.g., lack of dignity; legal implications of just war theory; IHL). In terms of LAWS, publications either focused on close-in weapons systems (i.e., point-defense weapons systems [38]); or loitering munitions [39]). Boisboissel [32] forecasts possible ways LAWS could be used in future warfare. As late as 2021, some researchers have been arguing that LAWS simply do not exist yet [16].

Since 2022 (search #2) increasing amount of papers focused on several instances of LAWS being used in real combat (mostly, again, as loitering munitions [6]). These have been used in multiple conflicts (e.g., Syria, Libya, Nagorno-Karabakh). The number of systems being used has spiked since the Russo-Ukrainian War (2022–) [6].

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