Modeling military action by using Artificial Intelligence

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Abstract: The technological revolution has led humankind into the digital age, where new technologies have brought significant advances in the domains where they have been used. The global security environment is undergoing significant changes in the poles of power, where spheres of influence and military actions have evolved with the use of emerging and disruptive technologies. Military capabilities equipped with the latest technological developments have delivered significant victories on the digital or physical battlefield. Thus, the military as a state entity has become a "beta-tester" for artificial intelligence, space technologies, autonomous and hypersonic vehicles, Big Data and advanced analytics, Internet of Battlefield Things (IoBT) with major impact on civilian specific research and industry. The military environment, by developing its capabilities and deploying emerging and disruptive technologies, is contributing to today's industrial revolution, demonstrating that the civil-military relationship is significant in a modern military. The aim of this article is to demonstrate the influence of the artificial intelligence (AI) in military actions, and the research methodology consists in the mathematical modeling of military actions by using Lanchester's laws for calculating the military power of the forces involved.

Keywords: Artificial Intelligence, Military Actions, Modeling, Military Capability, Operational Levels.

Modelarea acțiunilor militare prin utilizarea Inteligenței Artificiale

Rezumat: Revoluția tehnologică a condus omenirea în era digitală, unde noile tehnologii au adus progrese semnificative în domeniile în care au fost utilizate. Mediul global de securitate este supus unor schimbări semnificative în centrele de putere, unde sferele de influență și acțiunile militare au evoluat odată cu utilizarea tehnologiilor emergente și disruptive. Capabilitățile militare dotate cu cele mai recente dezvoltări tehnologice au adus victorii semnificative pe câmpul de luptă digital sau fizic. Astfel, armata ca entitate a statului a devenit un „beta-tester" pentru inteligența artificială, tehnologiile spațiale, vehiculele autonome și hipersonice, Big Data și analiza avansată, precum și pentru Internetul lucrurilor din câmpul de luptă (IoBT) având un impact major asupra cercetării și industriei specifice domeniului civil. Mediul militar, prin dezvoltarea capabilităților sale și implementarea tehnologiilor emergente și disruptive, contribuie la revoluția industrială actuală, demonstrând că relația civil-militară este semnificativă într-o armată modernă. Scopul acestui articol este de a demonstra influența inteligenței artificiale (IA) în acțiunile militare, iar metodologia de cercetare constă în modelarea matematică a acțiunilor militare prin utilizarea legilor lui Lanchester, pentru calculul puterii militare a forțelor implicate.

Cuvinte-cheie: Inteligența Artificială, Acțiuni militare, Modelare, Capabilitate militară, Niveluri operaționale.

1. Introduction

The recent history of Artificial Intelligence (AI) is closely linked to human development and the technological progress, but also to people's desire to be replaced from time-consuming activities or in hostile environments. The armed forces have continually adapted to national and regional security risks, threats and vulnerabilities, and emerging and disruptive technologies have revolutionized the way a military action is conducted, significantly influencing strategies, tactics and even the nature of warfare. The technological revolution has been capitalized by the defense industry, producing capabilities that are physically stronger and faster than the forces on the field.

The current conflicts have highlighted a new paradigm of warfare that the military power of a state or non-state actor is closely related to technological transformations and scientific achievements, and that scientific and technical progress has allowed the development of new areas in the defense industry that can ensure the success in planning and conducting a military action. In addition, the exponential evolution of technology is reshaping military actions, and new types of hybrid threats are being added to the elements of conventional warfare, which require the planning and conducting of military actions at all operational levels to be streamlined and adapted so that the

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military can fulfill its constitutional and legal missions. The AI revolution will enable the "cognitization of the machines, creating machines that are smarter and faster than humans for narrow task (Scharre, 2018)."

The introduction of emerging, disruptive and converged technologies into the modern military capabilities has significantly altered the relationship between combatant and non-combatant. In recent conflicts, armed forces have executed military actions with minimal human interaction, but with major impact on the operational environment. Driven by technological developments, the contemporary world will become, at least in the medium term, a space for the manifestation of interconnected risks and threats, which will increase the complexity, uncertainty and volatility of the global security environment.

Added to these trends is the increasing relevance of the military system and its implications for society. In the context of the development and use of military capabilities equipped with AI, it is brought to the attention of the military organization, as well as of the structures of the national defense, public order and national security system, the need to connect them to the technological progress, in order to "develop modern, highly operational capabilities, fully interoperable with allied and partner forces, which ensure the fulfillment of constitutional missions" (Administrația prezidențială, 2020).

In "Science and Technology 2023-2043 - Volume 1: Overview", the North Atlantic Treaty Organization (NATO) presented a definition of AI, describing it as the "ability of machines to perform tasks that normally require human intelligence – for example, recognizing patterns, learning from experience, drawing conclusions, making predictions, or taking action – whether digitally or as the smart software behind autonomous physical systems" (Donovan & Goldfein, 2019).

A military capability equipped with AI will perceive the operational environment, and with the help of technology will interact, reason and learn about the military action, and finally act in the operational environment to shape it.

In parallel to reducing human control over AI-enabled military capabilities and the efficiency and speed of decision making on the battlefield, human control remains to be discussed, at least in critical decisions with major strategic impact on national security or to prevent uncontrolled escalation of military actions.

The first section of the article provides an overview of the evolution of AI, followed by a literature review that examines key areas of AI application, with particular emphasis on current military capabilities. The subsequent section outlines the research methodology, in which mathematical modelling is employed in accordance with Lanchester's laws. Finally, the conclusions are presented, offering a critical assessment of AI integration into modern military capabilities and proposing potential directions for future research.

2. Digital warfare: revolutionizing military action through Artificial Intelligence

2.1. Evolution towards Artificial Intelligence

The beginnings of AI are closely linked to the army. Alan Mathison Turing (1936), a British mathematician and logician, introduced the theoretical concept of a Turing machine, a mathematical tool, in his paper "On Computable Numbers, with an Application to the Entscheidungs problem", and he is also the cryptanalyst who was at the head of the School of Codes and Ciphers at Bletchley Park, Buckinghamshire, UK, responsible for decoding and deciphering the messages of the German army in World War II and in the breaking of the Enigma code. Later, Alan Mathison Turing (1950) published a paper entitled "Computing machinery and Intelligence" in which he attempted to answer the question "Can machines think?" He is considered to be the founder of the Artificial Intelligence, the inventor of the Turing test, a practical test that tests the intelligence of a computer, and, according to some researchers, the test has been passed in 2022 by ChatGPT.

The first attestation of the use of Artificial Intelligence dates back to 1951, when the future director *of the Programming Research Group at the University of Oxford*, Christopher Strachey, wrote a program running on a Ferranti Mark I computer that managed to finish a chess game. However, the term Artificial Intelligence was brought up in 1956 by John McCarthy at a Summer Research Project on Artificial Intelligence conference held at Dartmouth College in Hanover, New Hampshire.

During this golden age of AI, two theories of its evolution developed, a theory by Marvin Lee Minsky, who argued that AI is based on computer logic, similar to If-Then-Else statements and Frank Rosenblatt's second theory, that AI must use neural systems similar to the screamer, the so-called connectionism. About this theory, the New York Times published in its July 8, 1958 edition an article entitled "The Navy revealed the embryo of an electronic computer today that it expects will be able to walk, talk, see, write, reproduce itself and be conscious of its existence (The New York Times, 1958)."

Since 1956, there have been several significant innovations in the field of AI, mostly related to academia (Taulli, 2019), shown in Table 1:

Table 1. Significant innovations in the field of AI in the 60's

Production year	Name	Creator	Short description
1961	SAINT or Symbolic Automatic INTegrator	James Slagle (MIT)	First expert system for solving calculus problems
1961	Unimate	George Devol	First industrial robot ever built
1963	ANALOGY	Thomas Evans (MIT)	Solved IQ test analogy problems
1964	STUDENT	Daniel Bobrow (MIT)	NLP system for solving algebra problems under Minsky's supervision
1965	ELIZA	Joseph Weizenbaum (MIT)	First chatbot, simulating a psychoanalyst
1965	DENDRAL	Edward Feigenbaum, Bruce Buchanan and Joshua Lederberg Stanford University	A chemical-analysis expert system
1966	Computer Vision	Gerald Jay Sussman (MIT)	First system to detect basic visual patterns
1968	Mac Hack	Richard D. Greenblatt (MIT)	First chess program to play in tournaments
1969	Hearsay I	Raj Reddy Carnegie Mellon University	Continuous speech recognition system
1969	SHAKEY	Charles Rosen, Nils Nilsson and Peter Hart Stanford Research Institute	The first intelligent mobile robot

Immediately after the 1970s came the first "AI winter", when interest in AI development and research declined significantly and with it public and academic interest in the field. Despite these challenges, some progress were made, in a number of fields, including the military. An expert system for use in medicine called MYCIN was developed, and DARPA (Defense Advanced Research Projects Agency) developed Harpy, a voice recognition system for fighter pilots. Although it proved impossible to implement, Harpy could understand 1011 words, similar to a three-year-old child.

The next decade, 1980-1990, was one of deep transformations in AI. Progress was limited technologically and economically. However, that period saw not only the development of expert systems based on Marvin Lee Minsky's theory in fields such as medicine, finance and automobile manufacturing, but also the development of neural network theories based on Frank Rosenblatt's theory. In 1986, a group of researchers wrote a groundbreaking article on neural networks, which represented an important milestone in the development of neural networks and machine learning, laying the foundation for many subsequent advances in this field (Rumelhart, Hinton & Williams 1986).

The evolution of computer technology and the amount of information available has allowed AI to advance significantly since 1990. Vernor Vinge, a science-fiction author and mathematician, published an essay (Vinge, 1993) entitled "The coming technological singularity: How to survive in the post-human era", in which he predicts a future in which machines overtake human intelligence and thus mark the end of the human race. In 1995, the Chabot A.L.I.C.E. (Artificial Linguistic Internet Computer Entity) was launched, which used the WWW for information gathering, and through a pattern-matching technique called AIML (Artificial Intelligence Markup Language), became much more adaptable than any other similar programs.

A major event in the development of AI capabilities was in 1997, when Deep Blue, a computer built by IBM, defeated the world chess champion Garry Kasparov. Much later, in 2015, Google DeepMind's AlphaGo, an AI system that could play Go, an ancient Chinese game, defeated a well-known European Go champion, Fan Hui. The following year, it defeated Lee Sedol, one of the world's most successful Go players. That victory was a revolutionary moment for AI, as the game of Go is a very complex game with over 2.1×1017 moves, and thus it demonstrated the power of Deep Learning. In addition, in 1997 the chatbot "Jabberwacky", developed by Rollo Carpenter, was released. He started developing the chatbot as early as 1988 and in 2008, he launched another chatbot "Cleverbot". Furby became the first robot pet, launched in 1998, and Cynthia Breazeal (Massachusetts Institute of Technology) launched Kismet in 2000, the first social robot that perceived and responded to human emotions. A study by Raina, Madhavan & Ng (2009) claimed that GPU graphics processing units were clearly superior to the existing multicore processors for AI learning tasks.

The year 2011 went down in history with the first contest won by an AI computer system. IBM's Watson won Jeopardy! (an American television game show) and Apple launched Siri, a personal assistant built into the operating system of the iPhone 4S. The following year, Jeff Dean and Andrew Ng conducted experiments with a neural network of 10 million unlabeled images from YouTube videos, and the neural network became responsive to images of cats, demonstrating the possibility of unsupervised learning autonomously from the information provided.

Sam Altman, Greg Brockman, Ilya Sutskever and Elon Musk founded OpenAI in 2015. Originally a not-for-profit company with the goal of promoting and developing AI for the benefit of humanity, it has been the foundation to AI development for the past 10 years and has come out with, among other things, a Chabot that revolutionized the digital world, ChatGPT.

2.2. The current state – through literature review

There is now a growing appetite for available AI tools or apps, and companies such as Microsoft with Copilot, Anthropic with Claude, but also companies from another geography, such as Deep Seek, China, which launched on January 27, 2025, an alternative to ChatGPT, have entered the competition.

In medicine, AI has revolutionized the delivery of healthcare through diagnostics, following the analysis of large amounts of clinical data and medical investigation to support decisions in complex conditions, treatment protocols, drug discovery, personalized medicine and patient monitoring. Also, with the help of AI, serious diseases such as cancer are being diagnosed much faster through a multidisciplinary approach, and in the case of radiology and medical imaging, it has facilitated the interpretation and processing of the images obtained, reducing waiting times and helped doctors prioritize critical cases (Akhtar, 2025). Artificial intelligence is also being used successfully in performance sport, to improve athletes' performance, accident prevention, fan engagement and sports management in general (Xu & Baghaei, 2025). In medicine, the use of AI can also have negative effects on patient care because it diminishes the human interpretation of the physicians. The ability of AI to interpret certain clinical outcomes is weighed against that of medical specialists. At the same time, the integration of the results and interpretations executed with AI bring new challenges to the clinical practice (Koçak et al., 2025). The adoption of AI in architecture, engineering and construction comes with several constraints, but also ethical issues. Several authors have identified nine ethical issues in the use of AI in architecture, engineering and construction namely: job loss, data privacy, data security, data transparency, decision-making conflict, acceptance and trust, reliability and safety, fear of surveillance, liability (Liang et al., 2024). When we bring up the use of AI in the organization, its impact on performance, but especially on financial profit, is well known. Institutions and organizations of all kinds, governmental or commercial, face pressures to implement AI in everything from management to replacing humans with autonomous systems, but at the same time are plagued by ethical dilemmas involving the responsible use of AI.

If we consider military actions, the potential use of AI is dual. Thus, it can be used to save the lives of military personnel by streamlining decision-making, but it can also be used to inflict as much damage as possible on the enemy, for example by analyzing data from the field and target acquisition. In this context, the design, development and use of AI must be carried out in compliance with the international humanitarian law, in order to limit the effect of its use in military action, to limit casualties among combatants and non-combatants, and to allow humanitarian organizations to be safe when intervening in an armed conflict.

2.3. Artificial Intelligence - a new military capability

Modern armies have understood that they need to engage and adapt to new technological developments, to understand both the enabling and destabilizing roles of the emerging, disruptive and converging technologies, and to develop capabilities to integrate them. The technological progress has often gone beyond the military domain, but its results have subsequently been successfully used in the defense industry.

After the end of the Cold War, resources for research and the development of new capabilities in the defense industry were significantly reduced. The new strategy for its development has focused on the dual use of new technologies, both in the military and in the private sector. The recent evolution and success of AI in the military as well as in society is to some extent also due to its dual nature. The development, production and testing of AI has been carried out both in military actions, through the use of AI-enabled capabilities, and in the business environment, through applications or different types of commercial devices or appliances.

The North Atlantic Alliance, through the NATO Science & Technology Organization has presented in the study "Science & Technology Trends 2023-2043 Exploring the S&T Edge - Across the Physical, Biological, and Information Domains" the potential impact, status and rate of development of the Artificial Intelligence, as well as the military fields targeted, shown in Table 2:

Table 2. The impact of AI according to NATO

Technology Focus Areas	**Impact**	**Production horizon**
Advanced AI	Revolutionary	2035 or (+)
Applications	High	2025-2030
Counter AI	Revolutionary	2030-2035
Human-Machine Symbiosis	Revolutionary	2035 or (+)

Several modern armies are equipped with capabilities that use AI to shape military actions. Through the use of methods for gathering information and documenting primary and secondary bibliographic sources, as well as methods for gathering, processing, and analyzing information available from open sources, the following military capabilities that use AI were discovered, see Table 3:

Table 3. Current military systems using AI

Name	Destination	Source
The Gospel (Habsora)	Acquisition of targets, mainly infrastructure, used by the Israeli Armed Forces.	(Schmitt, 2024)
Lavender	Target acquisition, mainly terrorists, used by the Israeli Armed Forces.	(Schmitt, 2024)
ARTEMIS	Infrastructure for the Processing and Large-scale Use of Multisource Information, used by the French Defense Procurement Agency.	(Machi, 2022)
Project Maven	Known as The Algorithmic Warfare Cross-Functional Team, uses AI to quickly analyze video captured by drones, used by the US military starting in 2021.	(Pellerin, 2017)
Harpy	Autonomous drones designed to autonomously search for and destroy enemy radars, used by the armed forces of Azerbaijan, China, India, Israel, South Korea and Morocco.	(Gagaridis, 2022)
Darktrace	An AI-based cybersecurity system that detects and responds to attacks in real time, used by the British Air Force and several civilian companies.	(Darktrace, 2025)
PALANTIR system	Data analysis software used by the US armed forces to identify patterns in data and improve decision-making.	(Larose & Rusch, 2024)
Ripsaw M5	An autonomous armored vehicle developed by Textron Systems, used for transport, logistical support and urban combat, first used in the Iraq conflict.	(Textron Systems, 2025)
Skydio X2D	An autonomous drone used by the US military for reconnaissance and patrol missions in dangerous areas.	(Skydio, 2025)

These are some of the existing capabilities in use, documented from open sources. In this context, given the development and production of military capabilities equipped with emerging technologies, there can be assumed that there are other capabilities using AI in the world's militaries, but information about them is classified.

2.4. The impact of Artificial Intelligence in military action

The contemporary military action is facing profound changes given the specific trends of the global security environment. The development of technology brings not only a revolution in the field of means of combat used in military action, but also support in all areas. In the paper (Congressional Research Service, 2019) "Artificial Intelligence and National Security" issued by the Congressional Research Service from United States, the current state of information about the use of military capabilities using AI in military actions, as well as their impact is presented, thus:

- Minimal impact: Military capabilities incorporating AI are at an early stage, with significant consequences in a significant timeframe. Safety issues in using AI-enabled capabilities. The development of military AI capabilities is closely linked to the development of generic technologies such as low-power microprocessors. AI capabilities and capabilities greatly diminish the confidence of commanders and reduce the willingness to use them in military action. Fear of change from classic decision following a classic planning process versus AI-assisted decision;
- Significant impact: AI can bring important improvements in the efficiency of the use of force in military actions and maximize the potential of the combat technology, but there is the possibility that it will evolve beyond the human limit, thus requiring human oversight and intervention. The very high psychological impact of using AI-equipped military

capabilities in conflicts against armies that emphasize physical strength and courage. The democratization of the AI technology will not create an advantage for one army or another and so no one will hold supremacy. The human role will be diminished, and the AI-enabled capabilities will make military actions less safe and controllable, as the AI has no feelings, emotions, legislative barriers;

- Revolutionary impact: The high potential of the AI-enabled military capabilities will challenge the laws and principles of an armed combat. Unpredictable actions of the AI-equipped military capabilities can cause unintended escalation or miscalculation. The AI-enabled military capabilities replace the military directly on the battlefield. Military and political decision-makers will make decisions at the strategic level, while the AI-enabled military capabilities will act exclusively at the tactical level. The ability of the weapon systems to collect, process and exploit information using AI can ensure victory in the decision space and will mean victory in the operational environment. The potential of the AI-enabled military capabilities is so great that it will call into question the laws and principles of armed combat, as known today.

The impact of the AI will lead to the evolution of the military actions and change the doctrines and field manuals, especially if it is used in conjunction with other emerging or disruptive technologies. AI used in conjunction with autonomous vehicles, hypersonic vehicles, advanced materials, space or quantum technologies will shape the work of the military leaders and redefine the knowledge for preparing, organizing and conducting military actions, as well as the theory of training and educating their forces.

However, there are significant challenges related to the use of the AI in military action. Ethical and political obstacles prevent a full integration of the AI into the operational environment, and an over-reliance on autonomous systems raises issues of trust and human accountability (Mayer, 2023). At the same time, the personnel policy will need to be reformed, reorganized, and prepared to meet the new requirements of the capabilities using the AI. Attention must also be paid to the international humanitarian law and its safeguards in the use of capabilities that conduct military actions without human control. Human control itself must be regulated, especially when there are major risks to the civilian population, similar to the existing treaties on conventional weapons or weapons of mass destruction. Last but not least, the use of the AI in military actions raises cybersecurity concerns and risks related to attacks on autonomous systems (Raska & Bitzinger, 2023) and altering their parameters to attack their own forces.

The AI therefore shapes military actions at all strategic, operational and tactical levels (Figure 1), depending on the importance of the objectives to be achieved and the echelon at which they are deployed, improving the efficiency and speed of response, but also raising new challenges and ethical dilemmas.

At the strategic level, one direction of action could be to use the AI to support decision making at the highest level through geopolitical and information analysis, strategic simulation and forecasting or the automation of the strategic decisions, reducing the response time of military, military and political decision makers in critical situations generated by military campaigns. At the same time, the national security can be ensured through AI-enabled cyber defense capabilities capable of protecting the critical and military infrastructures.

The powerful countries have revised their armament policy and national security objectives to embed AI into modern military capabilities (Johnson, 2019). Competing for geostrategic supremacy through military capabilities using AI are state and non-state actors that do not possess strategic nuclear weapons. However, the military nuclear deterrent capabilities at the strategic level, at this point in time, are far more reliable than those utilizing AI (Johnson, 2020) in potential campaigns.

Also, at the strategic level the AI can be used to destabilize the adversary by mass production and publication of fake news. In this situation, an AI-enabled capability can also respond to such an attack (Svenmarck et al., 2018).

In the category of the strategic military capabilities using AI, there can be mentioned the command and control (C2) systems, the command, control, communications and intelligence (C3I) systems, ISR capabilities, the defensive missile systems, the electronic warfare capabilities (mainly used against A2/AD systems), as well as the offensive and defensive cyber capabilities (Svenmarck et al., 2018).

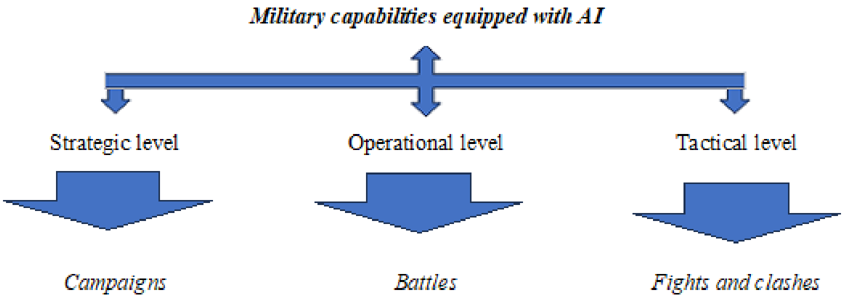

Figure 1. Operational levels and effects of the AI-enabled military capabilities (according to our own research)

At the operational level, the AI revolutionizes the process of planning and conducting military actions by analyzing a large volume of information from various ISR capabilities and it can adjust the courses of action of one's own troops or determine those of the enemy. By creating a Common Operational Picture (COP), the AI reduces the decision makers' response time and helps battle success. The AI will allow the operational level commanders an accelerated decision-making process to achieve objectives (Davis, 2022), by simultaneously developing multiple courses of action (COAs) for a single battle. At both the operational and tactical levels the use of the AI in decision making distracts the military decision makers from data processing and allows them to focus on tasks of human judgment and informing subordinates about the COA to be applied (Davis, 2022), knowing that an experienced leader intuits a more favorable COA. Of the capabilities that can integrate the military technology with AI, attention can be brought to systems for analyzing the intelligence as well as monitoring the enemy military systems, platforms, and troops (Johnson, 2020).

The tactical level, perhaps the most important one, where low-value objectives are accomplished but can easily influence the other two levels, is fundamentally transformed by the AI through the way direct combat or direct clashes are conducted. Autonomous systems, military robots, drones, modern command and control systems can execute missions in place of soldiers, across all weapons and specialties, and through image processing algorithms it can identify targets much faster, engage them with much greater accuracy, and assess the results and effectiveness of the battle or clash.

It should also be recalled that the interconnection of the three operational levels is essential, because the information obtained at the tactical level with the use of AI can influence a decision at the operational or strategic level. Last but not least, strategic decisions are much more effectively implemented at the tactical level by the AI-enabled capabilities.

3. Research methodology

The fusion of the AI and military action opens up a new art of war. Although compared to electricity as the invention that changed the world, the era in which AI capabilities play a major role in the military action can be compared to the Cold War, where the nuclear arms race reached its peak. While the role of the nuclear weapons and the AI-equipped military capabilities is that of deterrence, the major difference between these two stages of the geopolitical and military evolution is that the nuclear armament was based on supremacy through destructive power, the current era in which the AI increasingly holds control of the military actions is characterized by the computing power of the information systems it possesses. In addition, the development and possession of nuclear weapons has been limited since 1968 with the signing of the Nuclear Non-Proliferation

Treaty by 191 state parties (entered into force on March 5, 1970), whereas the policy of design, development and use of the AI is not exactly regulated even today, despite the warning signals advocated by world-recognized scientists such as Stephen Hawking (Cellan-Jones, 2014) or Elon Musk (Piper, 2018).

In order to demonstrate the role of the AI in modeling military actions mathematical modeling, based on Frederick William Lanchester's laws, has been used. Although the laws were introduced in the First World War to analyze the numerical and tactical efficiency and model the dynamics of the combat, they continue to be applied in the modern warfare, particularly to optimize the laws and principles of the armed combat, involving both the conventional forces and the asymmetric or hybrid elements, cyber-attack and modern weaponry. Lanchester's Laws give a mathematical perspective on how to achieve advantages in combat, even under conditions of numerical superiority or inferiority. The best example of a military action where a force with modern weaponry defeated a numerically superior force is the Yom Kippur War.

Lanchester's laws have been used to model and simulate past military actions to highlight any lessons learned. However, Lanchester's mathematical equations have also been used in the study of microorganisms and insects. Thus, studying cellular societies (e.g. myxobacteria and cellular slime molds), it has been observed that entities of this type that are larger in number have higher survival rates. In this context, the advantage of increasing the number of individuals, compared to their strength in a cellular society, indicates that the quadratic law fits better in the numerical dynamics of a cellular society (Clifton, 2020).

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Select model (type number 1-3 and press Enter):
1 - square law
2 - linear law
3 - modernized model
2
Enter number of RED units:
9000
Current value: 9000
Enter number of BLUE units:
3000
Current value: 3000
Enter combat efficiency of RED units:
0.00001
Current value: 1e-05
Enter combat efficiency of BLUE units:
0.00005
Current value: 5e-05
[OK] All parameters are collected.
Do you want to predict battle result now?
Type any char to continue or 'N'
to come back and correct input parameters
Predicted result of the battle (linear):
Winner: BLUE
Remaining RED units [ 1.4896492650105795e-05 ]
Remaining BLUE units [ 1200.0000029793 ]
Battle duration: 311 time steps
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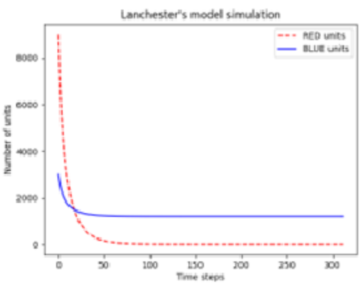

Figure 2. Lanchester demonstrated linear law (according to our own research)

In principle Lanchester's equations are similar, in the linear law the victorious armed force has both numerical and combat capability advantage (Jhonson & MacKay, 2015) of the efficiency of military capabilities, whereas in the case of the quadratic law, the victorious armed force has holds the advantage of combat capability, of the efficiency of military capabilities, similar as in the linear law, but now proportional to the square of its numerical size (Jhonson & MacKay, 2015).

Lanchester's laws can be applied, for the proposed modeling, as follows:

- the linear law, where the winning armed force (A), is given by the relation $\boldsymbol{\alpha} \times \boldsymbol{A} > \boldsymbol{\beta} \times \boldsymbol{B}$, where A and B represent the number of soldiers at the beginning of the battle, and **α** and **β**, are coefficients describing the efficiency of each army in eliminating enemies per unit of time; the strength of an army is directly proportional to its strength (Figure 2);
- the square law, where the winning armed force (A), is given by the relation $\boldsymbol{\alpha} \times \boldsymbol{A}^2 > \boldsymbol{\beta} \times \boldsymbol{B}^2$, where A and B represent the number of soldiers at the

beginning of the battle, and **α** and **β**, are coefficients describing the efficiency of each army in eliminating enemies per unit of time; it applies in modern warfare where technology allows the military to engage multiple targets simultaneously and shows that the strength of an army is proportional to the square of its strength (Figure 3).

To demonstrate Lanchester's laws, a program written in the Python programming language (Szczygliński, 2022) was used and the following results were obtained, with the mention that two generic armies were used with a force ratio of 3:1, where the red forces were 3 times larger than the blue forces.

By simulating Lanchester's linear law, there can be observed that at a force ratio of 3:1, the force smaller, but with a military action efficiency higher by only 0.00004. The parameter "combat efficiency" has natural values less than 1 and represents the individual efficiency of the military in direct combat. At the same time by the simulation of the quadratic law, at a force ratio of 3:1, but with a military action effectiveness 10 times higher than the blue force, it wins. In the case of this law, the parameter "average number of units that damage each other" represents the ability of an army to cause damage, being directly proportional to the number of soldiers.

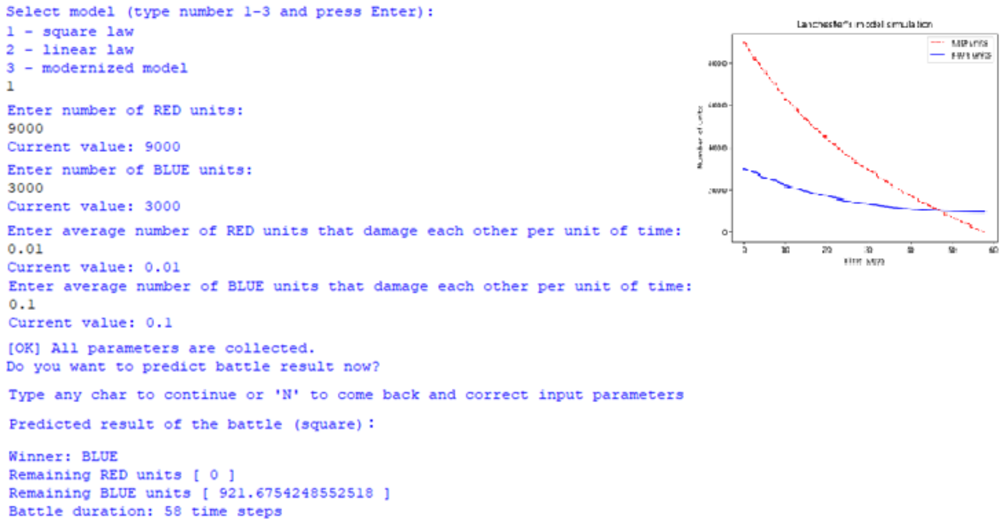

Figure 3. Lanchester demonstrated square law (according to our own research)

Modern conflicts have developed new approaches to the military doctrine, and terms such as the 4th generation warfare, hybrid threats or multi-domain operations are increasingly used. Lanchester's Laws have been used by military organizations to assess conventional force ratios through operations research and computer models in the context of the Cold War and the balance between the North Atlantic Organization and the Warsaw Pact (Lepingwell, 1987), as well as to analyze their applicability to the historic battles of Kursk and the Ardennes in World War II (Lucas & Turkes, 2003). Studies of the war in Afghanistan have brought attention to asymmetric conflicts (Bellany, 2002), where the technological superiority of a regular army may be diminished by external factors (terrain, guerrilla tactics) and direct confrontation is to be avoided to maximize the technological efficiency. Mathematical models of military actions are another weapon at the disposal of the battlefield commanders, allowing strategies to be devised based on the number of troops and their superior firepower. The Linear Law demonstrates that an army with a greater firepower is at an advantage over an army with a greater number of soldiers. In the same context, by applying the quadratic law, the technological advantage is counterbalanced by the greater number of soldiers. In practice, state and non-state actors that do not have a technological advantage within their own capabilities choose to increase the number of their soldiers.

Capability, whether defense or military, is the ability to execute actions to achieve objectives regardless of the operational level of military action.

When brought into focus, the term capability in other force structures in the world, it takes on new meanings (Taliaferro et al., 2019), thus:

- In the Australian Department of Defense, capability is defined as the ability or capacity to achieve an operational effect;
- In the Canadian Department of Defense, capability is the particular ability that contributes to producing a desired effect in a given environment, within a specified time, and sustaining the effect for a specified period;
- In the US Department of Defense, capability is the ability to accomplish a task or execute a course of action under specified conditions and at a specified level of performance;
- In the UK Ministry of Defense, capability is the enduring ability to generate an operational outcome or desired effect that is related to a threat, the physical environment and coalition partner contributions;
- In the Colombian Ministry of National Defense, capability is the ability to accomplish a task, within a specified set of standards and conditions (time, environment, distances, etc.) through a combination of capability components (doctrine, organization, equipment, infrastructure, etc.).

```
Select model (type number 1-3 and press Enter):

1 - square law
2 - linear law
3 - modernized model
3

Enter number of RED units:
9000
Current value: 9000


Enter number of BLUE units:
3000
Current value: 3000


Enter combat efficiency of RED units:
0.00001
Current value: 1e-05


Enter combat efficiency of BLUE units:
0.00001
Current value: 1e-05


Enter average number of RED units that damage each other per unit of time:
0.1
Current value: 0.1


Enter average number of BLUE units that damage each other per unit of time:
0.1
Current value: 0.1


Enter RED units AI capabilities: [current: 4]
0.1
Current value: 0.1


Enter BLUE units AI capabilities: [current: 4]
0.7
Current value: 0.7

[OK] All parameters are collected.
Do you want to predict battle result now?

Type any char to continue or 'N' to come back and correct input parameters

Predicted result of the battle (modernized):

Winner: BLUE
Remaining RED units [ 0 ]
Remaining BLUE units [ 403.3371723224344 ]
Battle duration: 88 time steps
```

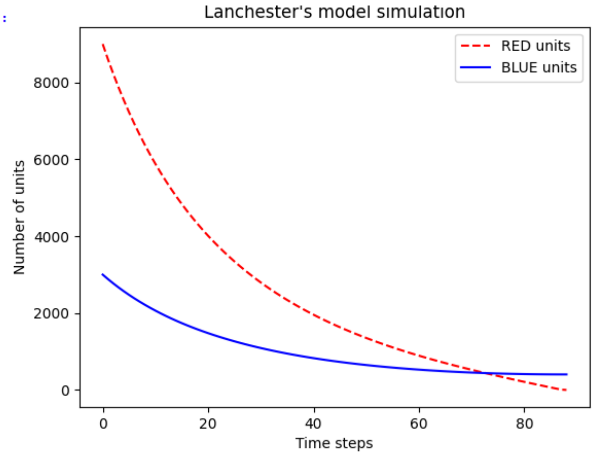

Figure 4. Lanchester demonstrated modernized law used in the 3:1 doctrinal ratio simulation (according to our own research)

The European Union defines defense or military capability as the ability to perform actions to achieve effects. It is defined by minimum requirements along identified lines of development (European Defence Agency, 2023).

To model military actions, Lanchester's laws were used, to which a parameter called weapon efficiency was added, taking into account the fact that armies equipped with AI capabilities have a higher combat efficiency. Thus, Lanchester's equations became:

- for the linear law, from the established formula of the winning armed force,

$\alpha \times A \times i_a > \beta \times B \times i_b$;

- similarly, for the square law of quadratic law, armed force A will win if the relation $\alpha \times A^2 \times i_a > \beta \times B^2 \times i_b$ applies.

In order to demonstrate that a smaller but technologically superior army can defeat a numerically superior army we applied the above formulas in a Python code. A coefficient called IA capability (**i_a** and **i_b**) was introduced into the equation, which was used as a general multiplier in the equations to determine the losses suffered among the military. Its value is less than 1, similar to the parameters introduced in the other two equations, but their values can amplify the effectiveness of the military actions.

Military specialists point out that different force ratios are required depending on the nature of the armed conflict. A study analyzing these ratios suggests 3:1 for the offensive actions and 1:1 for a counter-attack (Nistorescu, 2024), as demonstrated and illustrated in figures 4 and 5.

When entering the above data and using the linear law, there can be seen that at a force ratio of 3:1, the numerically superior force loses and the blue force is left with 409 soldiers, about 13% of the total initial force.

```
Select model (type number 1-3 and press Enter):

1 - square law
2 - linear law
3 - modernized model
3

Enter number of RED units:
9000
Current value: 9000


Enter number of BLUE units:
9000
Current value: 9000


Enter combat efficiency of RED units:
0.00001
Current value: 1e-05


Enter combat efficiency of BLUE units:
0.00001
Current value: 1e-05


Enter average number of RED units that damage each other per unit of time:
0.1
Current value: 0.1


Enter average number of BLUE units that damage each other per unit of time:
0.1
Current value: 0.1


Enter RED units AI capabilities: [current: 4]
0.1
Current value: 0.1


Enter BLUE units AI capabilities: [current: 4]
0.7
Current value: 0.7

[OK] All parameters are collected.
Do you want to predict battle result now?

Type any char to continue or 'N' to come back and correct input parameters

Predicted result of the battle (modernized):

Winner: BLUE
Remaining RED units [ 0 ]
Remaining BLUE units [ 8143.001652995518 ]
Battle duration: 11 time steps
```

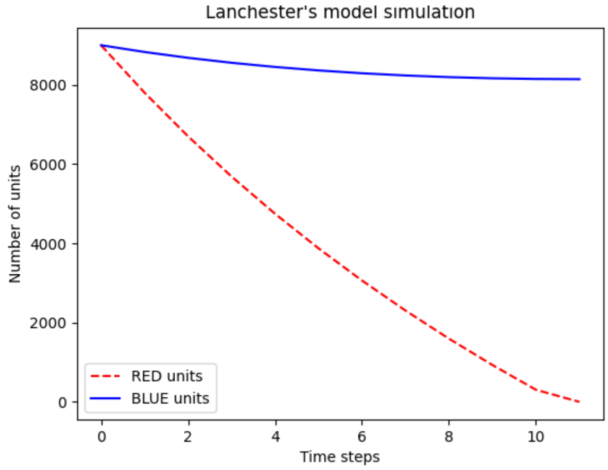

Figure 5. Lanchester demonstrated modernized law used in the 1:1 ratio simulation (according to our own research)

The comparative analysis of the two simulation scenarios clearly indicates the technological superiority of the blue forces that possess military capabilities equipped with AI. It can be observed the victory of the blue forces with losses of about 10% of the total forces, with 20 times the number of troops than in the 3:1 simulation. The empirical evidence indicates that the forces possessing AI-enabled capabilities can substitute the numerical superiority for the technological superiority in tactical engagements, with implications at other operational levels.

In conclusion, there can be stated that Lanchester's laws remain relevant to military action, in particular due to their flexibility and adaptability to new technologies and forms of conflict. The equations provide a mathematical model that can be used for decision making at all operational levels, regardless of its nature: conventional, asymmetric, hybrid or cyber. Last but not least, the successful application of the equations in military commands depends on their integration with other models and variables specific to the technological evolution and their impact on the development and transformation of the military actions.

4. Conclusions

In the new geopolitical context, with state and non-state actors promoting their global or regional objectives and interests through hybrid military actions, but especially conventional military actions, driven by technological developments, the contemporary world will become, at least in the medium term, a space for the manifestation of interconnected risks and threats, which will increase the complexity, uncertainty and volatility of the global security environment.

The AI revolution in the military marks a major transformation of the 21st century, redefining doctrines at all operational levels, with algorithms and autonomous systems becoming combatants in the military action.

The benefits are vast and compelling, in terms of reducing the military's exposure to the dangers of the military action by making command and control, communications, logistics, intelligence, force protection more efficient. Parallel to these opportunities are the ethical dilemmas that arise in the context of the delegation of decision-making in lethal military actions, as well as the risk of escalation of campaigns, battles and clashes through psychological detachment from their real consequences. Through the use of AI in military capabilities we are witnessing a process that goes beyond the concept of modernization of military arsenals and we are witnessing the transformation of the idea of military power.

These trends are compounded by the increasing relevance of the military system in the context of the development and use of new technologies, and the use of AI in military action may tip the balance towards small in numbers but highly technologized armed forces. Although Lanchester's laws have been defined by for more than 100 years, their application in the age of digital warfare remains topical and demonstrates that the numerical advantage of an armed force remains important only under certain conditions, especially when we are talking about a classic conflict where conventional weapons are used.

Finally, through the application of AI in military action, we are witnessing a fundamental transformation in the concepts of global and regional security. Today's society needs to manage the transition responsibly, and AI must be used to maintain peace and stability and not become a dangerous tool that generates new forms of armed conflict.

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