Developments in the Defense Industry With the Impact of Machine Learning and Artificial Intelligence

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Abstract: The defense industry has been one of the most popular topics in recent years. One of the most basic principles of the social state approach is to ensure the integrity of the state and to take the necessary security measures for the country. One of the main issues that cannot be ignored for states to live in peace and security is undoubtedly the power of the defense industry. States develop defense mechanisms against certain dangers by expanding their defense techniques. Therefore, with the development of technology, machine learning and artificial intelligence are among the most frequently encountered topics at this point. In this study, after a general overview of the defense industry sector, the defense industry in the world and defense exports in the world will be touched upon, and the connections of the defense industry with the fields of machine learning and artificial intelligence will be examined comprehensively.

1. Introduction

The Republic of Turkey needs more development in the defense industry every day due to its rich resources and geopolitical location. The defense industry in Turkey is developing and gaining value day by day. Achieving defense industry production in the world and in our country, reducing the need for external forces in this field, and increasing production is one of the most important and priority strategies of many countries.

In recent years, Turkey has made significant progress in the field of the defense industry and has pioneered the production and development of many domestic and national products. The aim of the studies is not only to produce weapons equipment but also to gain competence in high-tech fields. Upon examination of the literature pertaining to machine learning and artificial intelligence in the defense industry, it becomes evident that there is a scarcity of research conducted in this particular domain. Trifonov et al. (2017) outlined

some outcomes achieved at the Faculty of Computer Systems and Technology at the Technical University of Sofia about a project focused on the deployment of intelligent technologies to enhance security in computer networks. Mori (2018) examined the technological aspect of military innovation in the United States, with a specific emphasis on artificial intelligence. It is expected that artificial intelligence will play a crucial role as an "enabling technology" in the strategic struggle between the United States, China, and Russia. Reis et al. (2021) provided an analysis of the many modalities of autonomous intelligent systems within the military sector. Subsequently, an analysis was conducted to elucidate the ways in which these modes of operation contribute significantly to the technical advancement of the military sector. Stockbauer (2021) addressed the contentious association between the military and business with respect to the advent of artificial intelligence in the context of warfare. Nalbant & Bozkurt (2022) investigated the importance of artificial intelligence, machine learning, and electronic information in the expansion of the defense industry. Ali et al. (2023) investigated the progression and use of artificial intelligence inside the defense industry. Handra & Sundram (2023) conducted an analysis on the impact of the Human Resource Information System (HRIS) as well as the influence of artificial intelligence on the performance of the defense industry in the context of disruptive times. Galinec (2023) examined the relationship between cybersecurity and cyber defense in fostering cyber resilience, using a newly developed model of cyber resilience. Sabev et al. (2023) conducted an analysis of the use of artificial intelligence techniques in cybersecurity within the framework of Industry 4.0. Karydas & Leligou (2024) reviewed the research pertaining to a) attack and associated defensive mechanisms, b) reward mechanisms, and c) energy efficiency, while also presenting new

advancements in quantum technologies and brain-inspired federated learning systems.

The purpose of this article is to examine the importance of the defense industry, its historical evolution, and its current strategic role, and to conduct an in-depth study by considering the connection of the defense industry with artificial intelligence and machine learning. In the rest of the article, it is aimed at presenting broader and different perspectives on the subject by focusing on topics such as the components of the defense industry, the defense industry in the world, machine learning in the defense industry, and artificial intelligence in the defense industry.

2. Defense Industry History

In order to organize the defense industry more effectively, Turkey passed a law prioritizing this sector in 1998. Although there were efforts before the Republic of Turkey, the real development in the defense industry took place after 1923 (Ssb, 2023).

The General Directorate of Military Factories was established in 1921, and the Golcuk shipyard with repair and maintenance workshops and cartridge factories was established in 1924. During these years, in addition to some private enterprises, Tayyare ve Motor Turk Inc. was founded in 1926. It started operating in 1950, and 30 aircraft were produced in a private aircraft factory. Many aircraft were produced in the aircraft factory established in Ankara in 1944, and an aircraft engine factory was established in 1945 (Yesilyurt & Yesilyurt, 2019).

Over time, all military factories in the sector were incorporated into the Machinery and Chemical Industry Corporation (MKEK) in 1950. Over time, aircraft factories were also closed during the period when many factories were closed. In 1954, the R&D Department was established within the Ministry of National Defense, and the development of various equipment based on needs in the sector was initiated. Then, in 1970, the Technical Services Department of the Ministry of National Defense also

benefited from the work carried out for nationalization in the field of defense industry (Yesilyurt & Yesilyurt, 2019).

During the period of the Cold War, the proliferation of nuclear technology posed significant risks, prompting the defense sector to devise specific ways to counter the prevailing dangers. During a concurrent period, the space race exerted an influence on the defense sector as well. Over the past three decades, the conclusion of the Cold War has ushered in a new era in the defense sector. Significant advancements have been achieved in specific domains, including unmanned aerial vehicles (UAVs), electronic warfare (EW) systems, computing technology, and cybersecurity.

In contemporary times, the defense industry has emerged as a substantial sector encompassing a diverse range of technologies. The field of technology is undergoing continuous advancements in several domains, including artificial intelligence, cyber security, and autonomous systems. The defense sector plays a crucial role in safeguarding global peace and security and is anticipated to generate numerous advancements and breakthroughs in the foreseeable future.

Figure 1. Defense Industry (Freepik, 2023).

2.1. General Overview of the Defense Industry Sector

Public institutions and the private sector both produce the high-tech equipment required to safeguard the nation's borders in the defense industry sector. Incentives also support the positive figures reflected in the total turnover in terms of orders placed in imports and exports. With each passing year, Turkey carefully climbs the steps to achieve success in the world rankings with its companies that produce defense industry equipment. While the ratio of the world defense industry budget to the gross national product is 3%, this ratio is 5% in Turkey (Yalcin, 2021).

The defense industry is indirectly or directly connected to many sectors. The priority areas in which the defense industry interacts are as follows (Baran, 2018):

• Military Clothing Industry
• Missile and Rocket Industry
• Armored Vehicle and Military Automotive Industry
• Ammunition and Weapons Industry
• Electronic Industry
• Military Shipbuilding Industry
• Space and Aviation Industry

Figure 2. Defense Industry Related Sectors (Freepik-free-vector, 2023).

2.2. Defense Industry in the World

The defense industry around the world is advancing day by day. Ensuring production in the field of the defense industry and reaching the next level at this point is one of the basic strategies of almost every country. When we look at the field of defense industry in the world, while there was a decrease after the Cold War, there is an increasing trend after 2001.

There are two separate groups produced for defense purposes around the world. In the first stage, it is the meeting of certain needs of the soldiers, such as clothing and food, and in the second stage, it is the equipment and other tools produced for security and war. The services in the first group are no

different from private services and goods and can be easily met in the market if needed. In the second stage, certain conditions are accepted in which the rules of the perfectly competitive market for goods and services do not apply, and the buyer is usually the state. In such markets, efficiency conditions cannot generally be met. In cases of need, existing goods and services may be inadequate, or excessive costs may be incurred (Sezgin & Sezgin, 2018).

Figure 3. Military base (Freepik-free-vector-iso, 2023).

The rate at which countries produce in the field of defense industry is at a certain level. The defense industry is an area that requires a high level of capital and investment in R&D in order to be able to produce. Products produced in the field of defense are discarded at certain periods, losing their requirements without having the opportunity to be used. Due to the current situation, production in the defense industry is restricted. The majority of the countries engaged in defense industry and production in the world consist of a few developed countries. Only 43 of the 100 largest defense industry companies in the world are located in the USA (Sezgin and Sezgin, 2018; 2).

Table 1: Defense Exports in the World (WMEAT, 2017; Sezgin & Sezgin, 2018).

Countries	2005	2010	2014	2015	Share in World Total (%)
World	115,4	166,7	193,2	191,8	100,00
USA	90,6	129,7	154,7	158,9	82,85
Russia	5,0	7,9	10,6	9,4	4,90
Chinese	1,2	3,5	2,1	2,9	1,51
Germany	2,3	4,6	2,4	1,4	0,73
England	4,5	3,2	4,0	1,2	0,63
Israel	0,9	2,4	1,3	0,5	0,26
Turkey	0,2	0,4	0,4	0,4	0,21
Japan			0,1	0,1	0,05

3. Machine Learning

Machine learning techniques are considered a sub-branch of artificial intelligence. It is this situation that allows computers to be taught the work that needs to be done. Applications of machine learning methods are an area that we encounter at certain points in our lives, such as in finance, education, medicine, and automotive. One of the related fields mentioned is the defense industry (Tokmak, 2023).

Unmanned aerial vehicles are vehicles that can be controlled by remote command, have a lethal effect thanks to their weapons and ammunition, and can fly without a crew. All the components that include the necessary

equipment, infrastructure, and personnel required to control this aircraft are the common name of the vehicle and system. The equipment of the system that makes up this vehicle includes: (i) communication systems that provide communication with the operator or other systems of the vehicle; (ii) combustion engines, gas turbines, solar cells, and similar engines or propulsion technology used in vehicles; (iii) the load capacity it carries; (iv) the weapons it carries. Together, they form the entire unmanned aerial vehicle (Quintana, 2008; Ak, 2017; Tansu and Katranci, 2020: 341, 342).
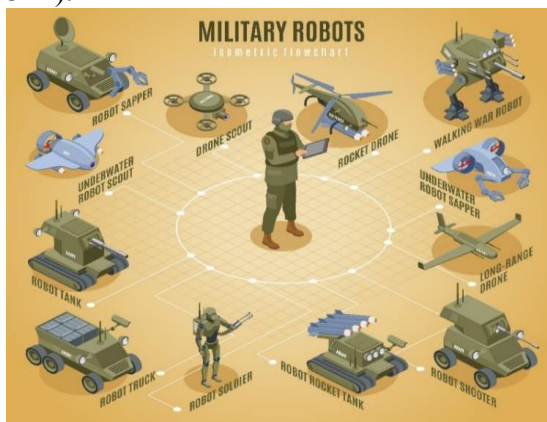

Figure 4. Military Robots (Freepik-free-vector-military, 2023).

Furthermore, it is imperative to acknowledge that the complete military efficacy of artificial intelligence can only be achieved through the integration of software and hardware, with the implementation of inventive operational concepts and organizational adjustments. As highlighted by a certain observer, it is imperative for sophisticated military forces to contemplate the manner in which artificially intelligent, deep-learning, autonomous systems might collaborate with or function independently of people in order to accomplish military goals that eventually pave the way for a political resolution of conflicts. The numerical value provided by the user is 77. In essence, it may be argued that the mere presence of technical advancements does not inherently result in corresponding advancements in defense capabilities. Rather, the effective use and integration of new technologies within a military organization need a well-defined military strategy to guide and coordinate these efforts. The successful implementation of military innovation necessitates the empowerment of individuals with expertise in new military capabilities. This may be achieved by altering the promotion routes within military organizations. However, it is important to acknowledge that such a change may result in disruptive consequences, leading to potential pushback from bureaucratic entities. According to Michael Horowitz, the incorporation of artificial intelligence into military or societal contexts is influenced not just by organizational politics but also by strategy or organizational culture. The numerical value provided by the user is 79. Relative speed and the integration of artificial intelligence into each country's armed forces are two important factors that will affect the future military trajectories of the United States and China (Mori, 2018).

4. Artificial Intelligence

Artificial intelligence consists of ways that enable machines to derive solutions to complex problems like humans and imitate living things in mental ways. It is the ability of codes consisting of ones and zeros to come together in the computer to make sense, to have human-like thoughts, and to derive certain solutions by making human-like analysis. In other words, it is the development of algorithms that are tried to resemble the human mind, providing the necessary training, and moving on to the implementation phase. The main purpose of artificial intelligence is not to imitate intelligence; on the contrary, the aim is to bring the actual software into a more advanced format (Tiftik, 2021: 377-378).

Artificial intelligence has established its existence in the scientific community as a computer or any supporting technological machine that produces solutions within the scope of human-associated features, perception, logical understanding, and the

development of high logic based on past experiences (Ozturk and Sahin, 2018: 24).

The main thing behind the artificial intelligence mentality is the ability to learn. Just as human beings need to learn before performing an action, the conditions are the same for artificial intelligence. One of the biggest and most important advantages of artificial intelligence is that it implements the fastest and most possible option after learning (Ozturk and Sahin, 2018: 26).

The correlation between artificial intelligence (AI) and employee performance is substantial. The level of employees' performance in completing job assignments is positively correlated with the accuracy, precision, and comprehensiveness of AI implementation. AI refers to the manifestation of machine systems that demonstrate certain facets of human intellect. These systems are extensively employed in many sectors and are currently recognized as a significant driver of innovation. AI refers to a set of technical components that are capable of gathering, analyzing, and responding to data in a manner that emulates human intellect. Similar to human beings, AI possesses the capability to enforce regulations, enhance its knowledge base

through the acquisition of fresh facts and information, and adjust its behavior in response to alterations within the AI ecosystem (Handra and Sundram, 2023).

Figure 5. Artificial Intelligence (Freepik-free-photo, 2023).

Table 2 draws attention to the fact that the failure mode is added during the stage of full autonomous control (level 8), when the computer works on its own unless something unexpected goes wrong. In the event that the fault is not included within the program parameters, it becomes necessary for the computer to request assistance from a human operator. The involvement of human people was not commonly taken into account at this particular degree, as evidenced in a seminal study on levels of autonomy conducted by Endsley and Kaber (Endsley & Kaber, 1999; Reis et al., 2021).

Table 2. A taxonomy for the levels of autonomy (Vagia et al. 2016; Reis et al., 2021).

Levels of Automation	Description
Level-1 Manuel control	The computer offers no assistance
Level-2 Decision proposal stage	The computer offers some decision to the operator. The operator is responsible for deciding and executing.
Level-3 Human decision select stage	The human selects one decision, and the computer executes.
Level-4 Computer decision stage	The computer selects one decesion and executes with human approval
Level-5 Computer execution and on human information stage	The computer executes the selected decision and informs the human
Level-6 Computer execution and on-call human information stage	The computer executes the selected decision and informs the human only if asked
Level-7 Computer execution and voluntary information stage	The computer executes the selected decision and informs the human only if it decides to
Level-8 Autonomous control stage	The computer does everything without human notification, except if an error that is not into the specifications occurs. In that case, the computer needs to inform the operator.

5. Artificial Intelligence in Defense Industry

Artificial intelligence (AI) has the potential to revolutionize several facets of human existence. Nevertheless, if it serves as a catalyst for advancement, it also functions as a driving factor. The issue has become a significant focal point for the military institutions of prominent nations in the twenty-first century. The convergence of civilian and military artificial intelligence (AI) can give rise to novel actors and applications. The acquisition of knowledge is of utmost importance in the context of warfare, as it serves as a foundation for the development of automated decision-making processes and streamlined workflows. The development possesses significant implications for nuclear strategy as it renders the existing plan obsolete and heightens the potential for nuclear war. Moreover, artificial intelligence (AI) and its many applications signify a significant paradigm shift in the realm of warfare management for forthcoming conflicts. Due to its significant role in determining superiority, it presents a substantial challenge to strategic stability (Ali et al., 2023).

Following the conclusion of the Cold War, the military industries encountered a critical juncture in their trajectory. Nevertheless, there is a resurgence in their progress thanks to cutting-edge technologies like robotics and artificial intelligence, which are enabling the development of autonomous, incredibly inventive, and transformative intelligent systems. Notwithstanding this recent momentum, uncertainties persist over the optimal allocation of scarce financial resources to enhance high-tech defense industries (Reis et al., 2021).

The domain of intelligent defense systems is now witnessing notable progress, which is enabling the emergence of sophisticated defense companies distinguished by elevated degrees of technical complexity. The military domain is undergoing substantial transformations and experiencing consequential effects as a result of the introduction and utilization of technologies such as robotics, artificial intelligence, and the internet of things. These technologies have garnered recognition for their capacity to generate autonomous intelligent systems, which are being incrementally advanced for military applications and possess the capability to operate efficiently in scenarios of war and combat. Hence, technology is frequently acknowledged as the principal driver behind several military revolutions throughout history, commonly known as noteworthy advancements in military capabilities or, alternatively, as profound transformations in military affairs. The ongoing change in military affairs is driven by three key factors. The rapid advancement of technology has facilitated the societal shift from the Industrial Age to the Information Age. Furthermore, the termination of the Cold War has exerted a substantial influence. Furthermore, the decrease in the defense budget within the United States has also had an impact (Reis et al., 2021).

5.1. The Utilization of Autonomous Intelligent Systems in Military Contexts

The military sector is now engaged in a growing body of research and development pertaining to autonomous defense systems across several domains, including space, cyberspace, air, sea, and land. In this context, we thus provide a comprehensive examination of the military utilization of autonomous defensive systems throughout the aforementioned sectors. The field of study encompasses space robotics and autonomous intelligence systems. Autonomous intelligent cyber-defense agents refer to self-governing and intelligent entities designed to protect against cyber threats. Intelligent unmanned autonomous systems, including aerial, maritime, and terrestrial domains (Reis et al., 2021).

The use of sophisticated applications in the fields of air, land, and sea has experienced a consistent rise. This may be attributed to the

emergence of intelligent, unmanned autonomous systems that are capable of executing tasks without human involvement, thanks to the integration of artificial intelligence. In this context, there has been a focus on enhancing the capabilities of intelligent unmanned aircraft systems to achieve autonomous flying, navigation, sensory perception, and decision-making capacities beyond those of traditional unmanned aircraft systems or unmanned aerial vehicles. Unmanned aircraft systems (UAS) and unmanned aerial vehicles (UAV) have become prevalent in their application for information, surveillance, and reconnaissance (ISR) operations, as well as for executing targeted offensive actions against strategically significant objectives (Reis et al., 2021).

5.2. Initial Vectors of the Third Offset Strategy

Deputy Secretary Work provided a comprehensive overview of the "initial vectors" of the third offset strategy during a seminar held at the Center for Strategic and International Studies (CSIS) on October 28, 2016. Robert Work (2016) provided an explanation of the underlying purpose of the third offset strategy, which aimed to enhance conventional deterrence at the operational level of warfare. To illustrate the components of this strategy, the author supplied a graphic (reproduced with permission) depicting the aims, ways, and means involved. According to the provided schematic, artificial intelligence facilitates autonomy for the majority of the technical systems shown in the upper box. The study explores the concepts of autonomous learning systems, collaborative decision-making between humans and machines, and the role of human assistance in these processes (Mori, 2018; 20).

The integration of operations, advanced man-unmanned systems operations, and networked, cyber and electronic warfare-hardened autonomous weapons and high-speed weapons would be implemented

within sensors, C4I (command, control, communications, computers, and intelligence), effectors, and logistics. These technologies would be utilized through novel operational concepts executed by innovative organizational structures. In aggregate, the utilization of autonomy would be strategically employed to successfully provide the necessary capabilities outlined in the lower section, which are essential for conducting operations in regions of contention and countering the capabilities of adversaries (Mori, 2018; 21).
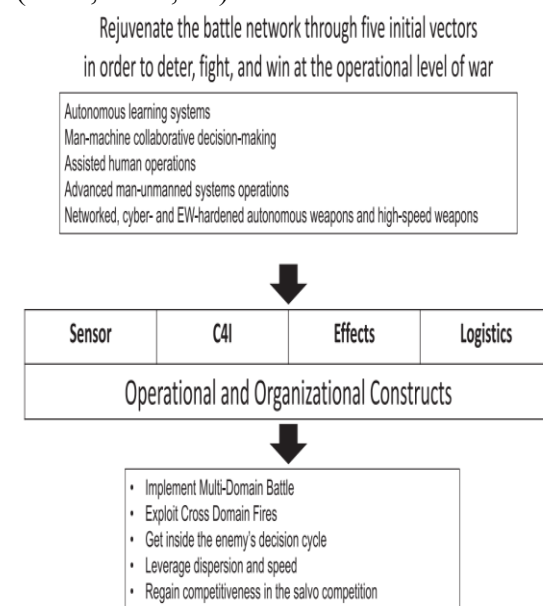
Figure 6. The Initial Vectors of the Third Offset Strategy (Robert Work, 2016).

5.3. The Importance of Machine Learning and Artificial Intelligence in the Defense Industry

The items generated by the military sector are of paramount importance not only in the context of warfare but also in fostering the advancement of our nation. Artificial intelligence (AI), augmented reality (AR), machine learning (ML), deep learning (DL), and robotics are integrated technologies that have been advanced in the field of warfare. These technologies enhance soldiers' situational awareness in war environments by facilitating rapid access to battlefield information. This access is achieved without the requirement

of traditional monitors or panels, thereby enabling information retrieval at the desired speed. The technologies developed by the defense industry offer several advantages, including border surveillance, intervention with improvised explosive devices, mine identification and neutralization, utilization in search and rescue operations, rapid and robust analytical capabilities, and various other aspects that may greatly aid our warriors. The anticipated rise in the utilization of artificial intelligence (AI) inside defense technology is likely to result in its ascendancy within the military domain (Nalbant & Bozkurt, 2022).

In the last ten years, there has been a notable emphasis on artificial intelligence (AI) owing to its extensive applications in both civilian and military domains. Despite its current classification as "weak AI" in present discussions, AI has the potential to play a crucial role in several aspects of national security in the future, despite its restricted range of skills. Recognizing the promise of this technology, the Member States of NATO have already commenced investing in it and have included it in their military policy. The development of AI has garnered considerable attention from various governments due to its strategic importance. These governments are actively involved in harnessing AI for a diverse array of military purposes, such as command, control, communications, computers, intelligence, surveillance, and reconnaissance (C4ISR) operations, cyber operations, and the utilization of autonomous and semi-autonomous machines. The potential of this nascent technology is in its capacity to make substantial contributions to the gathering and analysis of open-source intelligence (OSINT) and the extensive pool of information available on the internet. The function of this mechanism is to act as an initial screening tool for data, which is then evaluated by human personnel. Hence, it may be argued that AI possesses the capacity to mitigate the principal challenge linked to many realms of intelligence,

specifically the formidable magnitude of accessible knowledge. The potential incorporation of AI into the decision-making process at various levels of warfare, including tactical, operational, and strategic, holds promise in providing commanders with impartial and logical insights that are devoid of human emotions or other subjective factors that could potentially affect decision-making. Moreover, AI possesses the capacity to produce simulations and models, thereby allowing the investigation and evaluation of diverse methodologies. Considering the aforementioned considerations and the growing global momentum of AI, a multitude of ethical problems emerge regarding its application (Carlo, 2021).

6. Conclusion

The military sector possesses a rich and distinguished historical background, originating from several nations and global regions. The military sector has experienced a notable transformation in recent years, marked by heightened intricacy and inclusiveness in its operational framework when compared to prior periods. The complexity of this business has experienced a notable increase, rendering it more challenging to comprehend due to its intricate interconnections with several other disciplines. The defense industry is now in a significant phase of transformation and growth, wherein machine learning and artificial intelligence are increasingly recognized as crucial components in this evolution. The technologies are extensively utilized to a considerable extent in order to enhance threat identification, military operations, defense planning, and decision-making processes. This article explores the interconnectedness of machine learning and artificial intelligence in the military domain. The military business has a robust interrelationship with other industries, such as machine learning and artificial intelligence, autonomous systems, big data analytics, predictive modeling, and several other domains. Each of the above-listed

areas provides significant contributions to the subject of military studies. These technologies have the capacity to enhance the comprehensive management of military equipment, the operational efficacy of the military as a whole, and the promptness and efficacy of its response to hostile strikes.

As a consequence, the defense sector has experienced significant enhancements in its robustness and efficacy via the integration of machine learning and artificial intelligence technologies. However, the presence of these technologies places a significant burden of responsibility on governments and gives rise to serious challenges. Currently, it is imperative for nations to anticipate and proficiently address all potential occurrences while simultaneously implementing stringent measures at a strategic level. Artificial intelligence and machine learning are anticipated to maintain a substantial presence in the foreseeable future, exerting influence on the expansion of the military sector and offering potential resolutions to enhance worldwide security.

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