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OPPORTUNITIES FOR THE DEVELOPMENT OF MILITARY COGNITIVE SKILLS I (THEORETICAL APPROACH)

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ABSTRACT:

In this article, as the first in a series of articles, we look at cognitive intelligence, in particular the potential for cognitive enhancement in the military and the relationship with AI. This article provides the theoretical foundation for the second part, in which practical results and further research are analysed. By 2024, exploring the potential applications of artificial intelligence (AI) will have become a key area of civil and military research. New machine learning techniques and new computational skills have allowed previously unimaginable abilities to be explored. The results achieved have made dreams that were previously thought unattainable achievable and further results are expected in the near future.

KEYWORDS:

Artificial intelligence, automation, cognitive intelligence, military application, patterns of AI

1. Introduction

As a starting point, let's first look at the main challenges that researchers are facing and which are likely to be addressed in the coming years, with implications for the development of military cognitive capabilities. Artificial Intelligence has many applications, many of which are used by the military. To name just a few, these include automated drones, facial recognition systems, virtual assistants, cognitive automation tools, autonomous vehicles and predictive analytics applications. However, regardless of how AI is applied, all of these applications have common characteristics.

2. The relationship between human intelligence and Artificial Intelligence

Thousands of artificial intelligences have already been created by humans as part of the projects that have been implemented. The use cases of AI are illustrated in the figure below.

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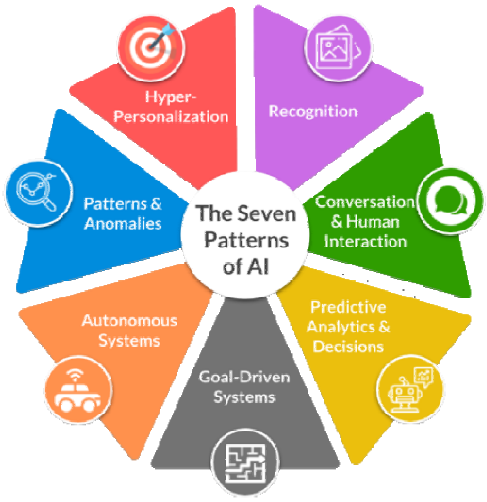

Figure no. 1: *The Seven Patterns of AI* (Source: https://www.forbes.com/sites/cognitiveworld/2019/09/17/the-seven-patterns-of-ai/?sh=6eea0d7512d0)

The figure shows seven patterns of artificial intelligence. Patterns from the civilian world can be applied to military operations, offering new ways to perform military tasks such as object recognition or decision support. In the following, we will examine some of the seven patterns of AI in terms of military applicability and research directions.

A hyper-personalization pattern means that once we have created an individual profile through machine learning, we learn that profile and apply it over time to achieve different goals. The four components of a hyper-personalization plan are decision making, data mining, design and dissemination. Of these components, the most important is the data creation because it is based on feedback. This feedback is called customer experience and is assessed in a similar way for soldiers using hyper-personalization. Hyper-personalization can increase the understanding of strategies and thus efficiency. The decision-making component of the hyper-personalization pattern also plays a huge role in military capabilities, particularly valuable in unmanned aerial vehicles/UAVs (Zhang et al. 2017). UAVs can collect huge amounts of data about the environment and potential targets using sensors, cameras and other data collection devices. The decision support component of hyper-personalization can be used to analyse this data in real time, providing military commanders with a practical tool to help them make more informed decisions.

Pattern Recognition (PR) is a computational method that can be used to objectively evaluate visual data. Pattern Recognition (PR) is a powerful computational method for objectively evaluating visual data. It does this by using supervised machine learning algorithm to search for patterns that, after learning on the patterns, are divided into a few subdivision groups. What this pattern can mean for armies. Effective command work requires team leaders to quickly read visual cues such as maps and coverages, so pattern recognition is key to effective command work. Army officers are given the right instructions and procedures, but they must also apply them on the battlefield. Commanders can use the samples to summarise their knowledge and thus help develop their expertise.

The importance of interactions between humans and robots is now evident in many industries. With the help of AI technology, this interaction is called conversational patterning, which refers to the interaction and back-and-forth communication between humans and machines. Over the years, solutions based on conversational AI patterns have been created that can be used by armies. In the modern workplace, information is transmitted between machines and humans through various media such as voice, text and images using AI. The main purpose of this pattern is therefore to enable machines to communicate with humans in the same way as humans do (Chase & Simon, 1973).

The development is important for armies because no dataset of military communication is as accurate as the datasets found through conversation patterns. Soldiers need them to carry out their tasks, in any environment, in order to carry out the orders they receive. The study of military conversation patterns is mostly concerned with creating conversation systems for similar situations and many countries have already made progress in the theatre of war using found military data. For example, by deploying a "talking" military agent, soldiers can get immediate, appropriate responses to a given situation, with less effort and cost.

In the civil sphere, *predictive analysis and decision-making* based on predictive analytics artificial intelligence has become more important than ever before for businesses to analyze consumer behavior and develop different marketing strategies. Additionally, using IoT (Internet of things) technology, another predictive analytics software option, can be useful for this task. Figure no. 2 shows the prospects that IoT has already shown in its application in the military sector.

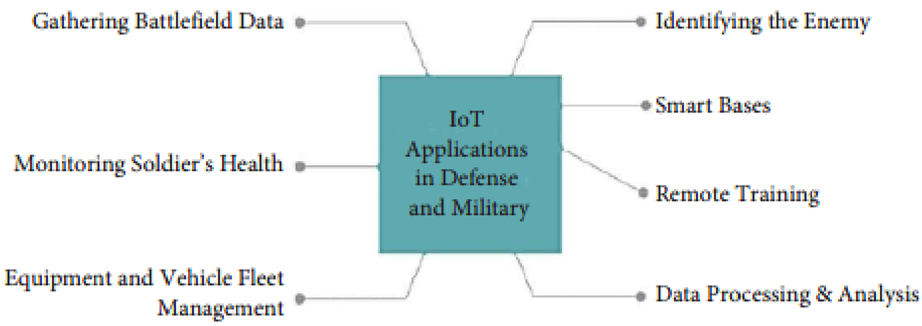

Figure no. 2: *Applications of the Internet of things (IoT) in defense and military*

Despite what has just been said, the military, unlike the civilian sector, currently makes even less use of predictive analysis.

The "*target-driven systems pattern*" is one of the seven patterns of AI with the highest signal quality. Its significance stems from the fact that this type of AI is also used to solve common problems that would otherwise require human cognitive abilities. The key to the solution is that AI has a unique concept called goal-driven autonomy (GDA), a concept that provides full autonomy to autonomous users. The system does not randomly detect problems, but only searches for them in relation to the current goals. This system is a fully goal-driven system, also known as a metacognitive integrated dual-cycle architecture ("MIDCA", "action-detection").

Autonomous intelligence, also known as autonomous system intelligence, is the most sophisticated type of artificial intelligence. In it, processes are automated to create intelligence that allows computers, robots and systems to behave independently of human interaction. Autonomous systems are most widely used by militaries around the world. Soldiers are taking advantage of the ability of such systems to anticipate events and plan for them, taking into account environmental parameters. Their capabilities facilitate the achievement of military objectives. Among military applications, one of the most important uses of artificial intelligence (AI) is unmanned autonomous systems with intelligence. These intelligent machines, designed by humans and equipped with state-of-the-art technology to perform or control tasks without human intervention, are called unmanned autonomous systems (UAS). The study of unmanned autonomous systems thus provides an opportunity to develop further applications.

The pattern called patterns and anomalies is the most commonly used pattern in various industries worldwide. In line with this, it is also prevalent in the military sector. One example is the detection of anomalies in advanced military aircraft using AI augmented neural networks and machine learning. Machine learning excels at performing rapid shifts within huge data sets and using this to detect abnormal IsK or outliers. This pattern can be applied in many areas. These include detecting fraud and risk and determining the extent to which events that have occurred are unusual or just what is expected. In addition, it can be used to find ways to collect data and can help reduce human error or correct mistakes that have been made. Another form of patterning is predictive text, which can examine speech and language patterns and use this to suggest more effective spelling of words. This helps the armed forces to better understand the battlefield and what the battlefield environment might look like. Armies in many countries are already using AI for tactical and strategic training of soldiers and cadets.

We can also say that the starting point is always human intelligence, as this will be the "template" for the AI. By default, we can distinguish three levels of intelligence:

– computational intelligence (the ability to calculate and remember quickly);

– perceptual intelligence (the ability to perceive vision, hearing and touch, including computer vision, speech recognition, language and translation);

– the level of cognitive intelligence (ability to understand, respond, reason and make decisions).

All three levels are linked to military tasks. Among the weapons and specialist teams that carry out computational tasks, we can highlight the artillery, technical teams and military meteorologists. The perceptual (perception) level can be of great importance for any task to be carried out in the theatre of operations. For example, it can relate to gunnery, reconnaissance and chemical defence teams. The cognitive level also has a multifaceted connection, as it appears at all levels of command decision making. In conclusion, it can be stressed that, in the execution of peace missions and "combat" tasks, military AI can provide all branches and specialised teams with a useful opportunity for development (Zhang et al, 2017; O'Hanlon, 2019b).

Another classification of intelligence is the technological classification, which includes the following groups:

– search solution (search technology);

– knowledge inference (inference method and verification strategy);

– machine learning (implicit models or massive sample data).

The search solution goes from problem definition to problem solving. In this process, different search technologies can usually be used, but the main question is whether all of them can be applied in the execution of military tasks. Such solutions can be Breadth-First Search (BFS), Depth-First Search (DFS), Uniform-Cost Search (UCS), Iterative Deepening Search (IDS), min-max search, alpha-beta pruning, Monte Carlo Tree Search (MCTS), best-first-search and A* search. Each of the listed search solutions should be considered separately before military application, especially from the point of view of security.

For the next group, the question of whether it is useful to soldiers no longer arises for the knowledge conclusion. All three forms (fuzzy logic, rule learning, expert systems) contain elements that can facilitate rapid and accurate military decision making. In fact, under the name of fuzzy logic, we can speak of a whole family of theories with a wide range of applications. Fuzzy logic has a wide range of applications in automation technology, business economics, medical technology, consumer electronics, automotive engineering, etc. Fuzzy logic is often useful when a mathematical description of a problem is not available or would be impossible or too costly to produce, but a common verbal, textual formulation is available. In such cases, fuzzy logic can be used to derive a mathematical formulation and description from sentences and rules used in normal human speech, which can then be applied to computers. (Swets, & Bjork, 1990; Li, Ota & Dong, 2018).

The second form is rule learning. A rule is a written or customary provision, a principle, which prescribes or determines our conduct, behaviour, or procedure; to which we must conform or conform. A rule can be described in the form “if ... then”. A rule is learned by using the experience (data) already available by learning a set of rules and distinguishing them from unknown examples. The primary aim of rule learning is to produce a set of rules. This rule set can cover several patterns and thus serve as a commonly used pattern for sequential overlap. Armies always operate according to predefined rules. If these rules can be improved and adapted to the different planned tasks with the help of AI, it can be a great help to commanders in their decision making.

The third form is expert systems. An expert system is a combination of large amounts of software, expertise and experience. The expert system is a combination of a large number of software systems, expertise and experience. The AI technology and computer technology are used to develop arguments and make judgements. An expert system is therefore a computer program system that simulates human expertise to solve problems. Its basic components are the knowledge base, the reasoning engine and the working memory. Expert systems are currently involved in the execution of military tasks. (NATO, 2020; Spain, Priest & Murphy, 2012; O’Hanlon, 2019).

Machine learning is a branch of Artificial Intelligence (AI), dealing with systems that can learn, i.e. generate knowledge from experience. In practice, this means that the system is able to recognize and define rules based on example data or patterns, either autonomously or with human assistance. The system therefore not only learns the patterns “by heart”, but is also able to generalise from them in such a way that it can make “correct” decisions about unknown data at the end of the learning phase. Machine learning is essentially a form of perceptual (perceptual) reasoning, in which intuition is able to learn from massive amounts of sample data. Perceptual thinking allows commanders to not only make judgments about the enemy's possible movements and positions, but also to make quick decisions based on empirical intuition. The primary problem is that this process sometimes leads to wrong conclusions. However, this can also occur in command (“human”) decisions, for example when the enemy acts contrary to expectations. Machine learning includes:

– Supervised Learning;
– Unsupervised Learning (data mining);
– Unattended learning (Unsupervised learning);
– Deep Learning.

Supervised learning is a type of learning process. It is when the system has many sample inputs and expected outputs associated with those inputs. The system then tries to learn a function that gives an appropriate mapping to the sample inputs and has an appropriate generalization speed. In *unsupervised learning*, the model is not supervised. The model works by itself to predict the results. It uses machine learning algorithms to infer inference from unlabeled data. In general, unsupervised learning algorithms are more difficult than supervised learning algorithms because there is little information. Clustering is a type of unsupervised learning. It can be used to cluster unknown data with the help of algorithms (Porkoláb & Négyesi, 2019; McDaniel & Einstein, 2006; Lackey, Salcedo, Matthews & Maxwell, 2014).

In *reinforcement learning*, a model learns the deployment by gradually rewarding correct predictions and penalizing incorrect ones, so it is a self-learning system. Reinforcement learning follows a defined methodology and determines the best ways to achieve the best outcome. *Deep learning* has defined the past years of artificial intelligence research, with almost the entire field focusing on learning algorithms and learning systems. It seems that this phase in the history of AI, with its many major achievements, may soon be coming to an end (Sha, Chen, Gao & Li, 2021; Deng & Yu, 2021; Li, Zhou & Chen, 2018).

So, in this section, we have looked at the level of cognitive intelligence, in terms of military intelligence, where the first challenge is to create human-level artificial emotional intelligence. The goal is to have machines that interact with humans also use emotions to make decisions and generate behaviour. In particular, this could enable AIs to develop long-term social relationships with humans, with all the legal and ethical implications that are now attracting increasing attention. For people, emotional intelligence enables and motivates their actions and decisions, and the choice of goals they set. Emotional intelligence therefore occupies a key position in responding to challenges. We can say that it is not only the ability to recognize and express emotions, which is why most research, including military research, is currently focused on answering this question. Military research has shown that both skills are needed, but the connecting part, emotional intelligence, is more important and harder to understand.

The second challenge is to understand the context of what is happening. In practical terms, this means that, on the basis of the information available, the AI must independently process and continuously update past and future events, define its role in them, and then set specific goals and, on the basis of these goals, develop plans to achieve them. This ability is called "narrative intelligence" (Paisner, Cox, Maynord & Perlis, 2014).

The third challenge is to achieve human-like active learning. AI "behaves" like a human and develops a set of values that motivate its learning process. The AI's "value system" helps the learner to choose tools to test hypotheses, search for available resources online or interview a person (human). It is essential that the AI seeks these tools on its own initiative to achieve its learning goals. If this is achieved, the AI will be able to grow autonomously, from the child level to the human adult level and beyond. This capability can be called "human-level learning intelligence" - distinguished from "deep learning" and other forms of machine learning popular today (Campbell, Cantrell, Generalao, Sawyer & Takitch, 2006; Chuang & Cheng, 2022).

3. The "military" artificial intelligence

In the light on the foregoing, let us define the concept of military artificial intelligence. We create a concept despite the fact that it may generate debate. Many people say that there is no such thing as military AI, we can only talk about the military use of AI. Others say that if there is a concept of military IT, then there must be a right to have this concept. In this article, we do not want to take a specific position, but we would like to highlight factors that may help us in our decision.

Four facts help to define the concept of militarily relevant AI. First, AI such as military AI cannot exist in a vacuum, i.e. in isolation from other AI applications. Instead, they are mutually reinforcing, leveraging the effects of existing advanced capabilities, thereby reducing the decision timeframe associated with warfighting. Second, military AIs can have an impact on stability, deterrence and escalation if a state realizes its functionality and capabilities. In the case of nuclear policy, interpreting an adversary's capabilities and intentions in a broader sense, based on deterrence and strategic calculations, is as important as its actual capabilities. In addition to the important military capabilities and doctrines, AI also has a strong cognitive element, which increases the potential for future escalation as a result of inadvertent misunderstanding and miscommunication. Thirdly, an increasingly competitive and contested nuclear arsenal will compound the destabilizing effects of AI, but will increase the risk of escalation of future warfare between the major military powers. The developmental and strategic advantages offered by AI-enhanced capabilities may prove irresistible to strategically rival states with nuclear weapons. Thus, the motivation among adversaries to circumvent the limitations of AI, compromising security through technological super-readiness on the digital battlefield of the future, increases. Finally, in this context of inadequate geopolitical context, the perceived strategic advantages of AI are likely to attract states to transfer technologies. The importance of military AI is also underlined by the words of US President Donald J. Trump, who stated that "US leadership in AI is paramount to maintaining the US economy and national security".

Military AI applications can be broadly categorized and linked to civilian applications. They can be useful primarily at the operational or strategic level of warfare. At the operational level, applications include autonomous weapons and robotics (especially drones), big data-driven modelling for intelligence analysis, deployment of mobile missiles, submarines, mines, and troop movement and surveillance. At the strategic level, applications include intelligence, survey, reconnaissance and command and control. In addition to these, communications, C3I systems, enhanced missile defence with machine learning augmented automatic target recognizers, the development of command and control systems, the development of conventional precision guided munitions and electronic warfare to improve air defence, as well as defensive cyber capabilities can be developed with the help of artificial intelligence. While the potential strategic impact of military AI is often not spectacular and not exclusive to this technology, the trend shows that it can be a serious concern in a pessimistic approach to the study of instability-stability (Blankenbeckler, Graves, & Wampler, 2014; Brunyé et al., 2020).

To better understand the nuances of AI, it is first important to understand the difference between an automated and an autonomous system. An automated system is one in which a computer operates this is justified by a clear, rule-based structure and executes this deterministically, meaning that for every input the output of the system will always be the same (unless something fails). An autonomous system is one that probabilistically reasons about the set of inputs, meaning it makes suggestions about the best possible courses of action when sensor data is input. Unlike automated systems, if someone provides the same input, autonomous systems do not necessarily result in exactly the same behaviour in all cases, because such systems can result in a wide range of behaviours.

The automation of driving is relatively recent, being a product of the second half of the 20th century. The automation of driving was based on the results of the scientific and technological revolution. The qualitative changes in "man-machine" systems occurred when technical equipment was developed that could perform some essential function of human activity or of the production process more efficiently than a human. This was considered to be the first step in the modernisation of man-machine systems, and thus the beginning of automation. Accordingly, in the military field, the principles of the time stated that automated command and control systems included the command and control systems of subordinate military organisations (formations), their armaments and technical equipment, including automated and automatic command and control systems for their combat equipment (Brunyé, Smith, Horner & Thomas, 2018). The following list also shows the technical means that could be used in automated command and control systems:

– Information gathering tools (airborne, radio, radio technical and other reconnaissance);

– Data recording devices (perforators, typewriters, printers, tape recorders, tape recorders, copiers and duplicators);

– Data processing equipment (tabulators, calculators, electronic computers);

– Information conversion equipment (reading and coding equipment, conversion equipment, microfilm making and reading equipment);

– Information-exporting equipment (automatic printing equipment, electronic tabulators, on-screen display equipment, automatic graphic-drawing machines);

– Information retrieval and storage equipment (card indexers, document sorters, specialized high storage capacity information and multi-purpose electronic computers);

– Communication equipment (teletypewriters, telephones, radios, radio relays, telecoders, commutators, selectors, document transmitting (teletypewriter) equipment, paging equipment for senior staff).

The allocation of specific tasks, which allowed both the preparation and the subsequent implementation of targeted improvements. On this basis, the following key features of automated team management systems have been identified:

– to increase the effectiveness of the means of combat;

– use the various means of destruction more economically;

– increase the immunity of own troops;

– to assist the effective action of commanders and staffs;

– to provide commanders and staffs with information reflecting the situation;

– increase the operationality of the command;

– improving cooperation between commands and within the troops.

In addition to defining the principles, the decision-makers also addressed the practical implementation issues. Several options for implementing automation were envisaged:

– autonomous (local) deployment of automation tools in the trunks;

– the creation of autonomous automated systems in the different formations;

– the creation of complex automated team management systems.

The starting point was the identification of two basic tasks for the modernization of team management systems and processes, and the recognition that modelling and formalization would play a key role in the process of automating and optimizing team management. The two core tasks were:

– To create the necessary conditions and technical tools to ensure a high degree of operationality in management;

– to make management more effective, in particular by improving the soundness and accuracy of decisions.

The simplest division of tasks was the group of peace-keeping and war-keeping tasks. In peacekeeping, computers were used for a wide variety of tasks:

– developing the main concepts for the structure of the armed forces;

– the preliminary evaluation of the war command's operational plans and the modelling of combat situations on the basis of that evaluation;

– tasks related to ensuring the combat readiness of troops;

– planning and execution of mobilisation;

– preliminary assessment of the likely enemy's combat capabilities;

– assessing existing weapon assets and developing requirements for planned assets;

– carrying out control and financial operations.

The future of AI in military systems is directly linked to the ability of engineers to autonomously design systems that demonstrate the independent ability to reason knowledge-based and expert-based. At present, such fully autonomous systems do not exist. Most robots are remote-controlled from the ground, essentially meaning that a human still directly controls the robot from some distance, as if doing so via a virtual extension cord. Most military UAVs have some low level of autonomy that allows them to navigate without human intervention, but almost all of them carry out their missions with significant human intervention. Even those that fly over a target to take pictures and then return autonomously to their point of origin are still operating at an automated and non-autonomous level and are not "true" autonomous systems on the fly (Gao, Chen, Zhang & Gao, 2019; Prelipcean, Boscoianu & Moisescu, 2010). Current operating systems are not yet automatic, but rather autonomous, although there have been significant efforts in the world to research and develop autonomous systems. Progress is being made in the development of such military systems in many countries for air, land, water and underwater vehicles, with varying degrees of success. There are already several types of autonomous helicopters that can be piloted by a field soldier using a Smartphone, and these are under continuous development in the United States, Europe and China. Autonomous ground vehicles such as tanks and transport vehicles are under development worldwide, as are autonomous underwater vehicles. In almost all cases, the agencies developing these technologies struggle with operational implementation. This is for a number of reasons, such as cost and unforeseen technical issues. At the same time, organizational and cultural differences between developers are problematic and can be barriers in their own right.

Military decision-making requires ever greater capabilities and ever more information from the battlefield. Military decision makers must select and effectively filter information in a timely and effective manner during mission execution. Human capabilities to analyse all the data are no longer sufficient, because the modern battlefield is subject to rapid dramatic and unexpected movements, chaotic situations can arise, even in repeated cases. Artificial intelligence enables the analysis of a wider range of possibilities, allowing personnel to analyze additional possible options, along with a deeper analysis of those options, in the same time interval.

In summary, AI can support every step of the military planning process:

– initiation, which corresponds to mission initiation and mission reception;

– orientation, which includes mission assessment, mission statement, and decision-maker planning guidance;

– concept development, which includes analysis of friendly and enemy forces and decision-maker estimation;

– a decision on how to implement, approval of the action, review of critical points;

– drawing up a plan, mainly synchronization and finalization;

– plan review, which involves analysis and revision of plans.

In the future, the various conflicts will take place on battlefields shaped by artificial intelligence and other new technologies. Some other observers suggest that this change will be revolutionary if the world is ruled by an AI leader, and that war may soon be waged without human involvement. This theory may be tempting, of course, but even if we believe in the transformative potential of technology, the hope that robots will replace humans in warfare is unrealistic. Human innovation, however, has already overcome technological disadvantages to lead to victory those who are quickest to exploit the battlefield.

Autonomous systems and advanced artificial intelligence systems are already outstripping the capabilities of human forces, displacing human labour alone. Autonomous systems have so far been rather limited, using fixed rule sets and different levels of control, but not solving the problem of direct human control. Increased use of AI will allow autonomous systems to play an increasingly important role in more precise decision-making, in controlled activities and, at the same time, increasingly establish complex human-machine collaboration. Autonomous systems provide rapid analysis, advice, and action learning to support strategic-operational-tactical planning, enabling increased OODAs and bringing a completely different perspective to old problems no longer constrained by old strategies. Such smart military networks increase decision speed to a level that requires new methods of human-machine interaction and visualization. The result is that competition between battle networks generates increased evolutionary pressure on algorithms, each seeking effects that can lead to decisive victory. Similarly, autonomous vehicles enabled in this way increase their effectiveness throughout the conflict, creating large sensor networks. The second military development direction is the development of agile and adaptive C4ISR networks. If the links are seamless and ubiquitous, increased reliance on the links will increase the performance of the networks in cyber disinformation activities. Such attacks should be implemented well before the conflict begins. From a logistical perspective, they can indirectly attack modern operational and strategic personnel, information, financial or other support elements, networks.

As the operating environment expands to include space, cyberspace and the wider information sphere, the need to think, plan and operate in a widely interconnected and multi-domain way becomes even more important. With the growing number and widespread deployment of multi-domain sensors, multi-domain networks, there are increasingly embedded growing processing capabilities for dominance, counterspace capabilities, defence, countermeasures and other secondary functions. Increased exploitation of new domains will inevitably lead to the search for domain superiority, with associated costs and capability requirements.

In conclusion, we believe that, based on the above, it is justified to treat the concept of “military” artificial intelligence as a separate concept within the conceptual framework. This is also shown by the trends in military development, which show significant changes in seven categories of technology areas (the categories are: chemical sensors, biological sensors, radio communication, laser communication, radio frequency weapons, non-lethal weapons and biological weapons). In the remaining categories of key military technologies, many of which use sensors or major components of weapons platforms, progress has likely been modest or moderate (e.g., land combat vehicles, aircraft, ships, and missiles). Importantly, however, apart from robotics, any of the remaining technology areas have undergone truly revolutionary change (O’Hanlon, 2019a).

4. Conclusions

The seven patterns of artificial intelligence have revolutionized military operations and offer additional new opportunities for developing military capabilities. The analysis of the seven samples represents one of the basic points for further research. This article also shows what the levels of human intelligence are and how to develop the level of cognitive intelligence, which is tied to commander decision-making with countless connections. In the third main part of the article, we introduced a “new” controversial concept, the concept of military artificial intelligence. By clarifying all these concepts, our main goal, in addition to clarification, was to prepare the second part of the series of articles, in which we already dealt with questions of practical implementation.

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