

**POTENTIAL ROLE OF ARTIFICIAL INTELLIGENCE IN THE
DEVELOPMENT OF FIELD ARTILLERY**

Author:

Géza Gulyás (PhD)
Nemzeti Közszolgálati Egyetem

Reviewers:

Norbert Daruka (Ph.D.)
Óbudai Egyetem BGK

Zoltán Nyikes (Ph.D.)
Milton Friedman Egyetem

E-mail:

Gulyas.Geza@hm.gov.hu

...and two more anonymous reviewers

Absztrakt

*A MESTERSÉGES INTELLIGENCIA LEHETSÉGES SZEREPE
A TÁBORI TŰZÉRSÉG FEJLESZTÉSÉBEN*

A mesterséges intelligencia már ma is mindennapjaink megkerülhetetlen szereplője és szerepe a jövőben – minden bizonnyal – tovább fog nőni. A cikk, egy rövid elméleti magyarázatot követően azt vizsgálja, hogy a tábori tüzérség különböző részterületeinek (tűzérfelderítés, harc- és tűzvezető rendszerek, fegyverek és lőszer) fejlesztésében milyen szerepet kaphat a mesterséges intelligencia. Az anyag végén pedig egy ma még meglehetősen kidolgozatlan területre hívja fel a szerző a figyelmet, a mesterséges intelligencia alkalmazásának etikai kérdéseire.

Kulcsszavak: mesterséges intelligencia, tábori tüzérség, tűzvezetés, célszerzés

Diszciplínák: hadtudomány, informatika

Abstract

Artificial intelligence is already an unavoidable player in our everyday lives and its role will, certainly, continue to grow in the future. The article, after a short theoretical explanation, examines the role that artificial intelligence can play in the development of different areas of field artillery (artillery target acquisition, fire control systems, weapons and ammunition). At the end of the study, the author draws attention to an area that is still quite undeveloped today, the ethical issues of the use of artificial intelligence.

Keywords: artificial intelligence, field artillery, fire control, target acquisition

Discipline: military science, informatics

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I always learned from my teachers that a well-chosen title is half the success since it attracts the attention of the readers or audience. However, attention and interest are, in the best case, followed by expectation, which must be met. Well, in the next few pages, I will try to meet this expectation and, after clarifying some theoretical concepts, outline a kind of possible path for the development of field artillery.

The title actually contains three ideas: field artillery, artificial intelligence (hereafter: AI), and finally the future. I think the question of field artillery is the simplest, and the majority of readers have some idea about it. This knowledge will be enough to understand this study. AI is a somewhat more difficult question, since first of all we need to clarify what intelligence is, in order to understand its artificial type. Understanding of it is very important, as it would be impossible to deny that AI will transform all areas of our lives in the future. But the projected future is pure speculation. When the question of the future and AI comes up in my lectures, I usually tell the students that...

...today we are still thinking about what to do with artificial intelligence, but if we are not careful in 30 years, artificial intelligence will be thinking about what to do with humans.

Why is it worth thinking a little about this? Because it is in the basic interest of every armed force to develop and to adapt its developments not primarily to the present, but rather to the foreseeable future. This was not an easy task, considering the efficiency of the experience processing systems and the developments of the last hundred years, and so it probably will not be in the present either...

However, we must understand that AI has already become an indispensable tool in many fields, it has transformed and developed the tools and processes of our everyday life, thereby, ultimately, increasing and will certainly increase their efficiency (see: Mező és Mező, 2019). And this statement, it seems, will be true in the field of warfare as well.

The term “intelligent artillery” appears more and more frequently in military literature worldwide. However, currently, there is no accepted definition of this term, and the research mind may meet a mass of vague, perhaps somewhat confusing ideas. I myself do not wish to increase the number of theories, so in this short essay, I will rather direct the reader's attention to those areas of field artillery where the appearance of AI is likely to be expected in the near future. Nowadays, it appears that AI can be involved in the following theoretical functions within field artillery:

- automatic positioning
- automatic detection and analysis
- automatic identification
- independent judgment-making
- independent decisions
- starting an independent fire/destruction
- automatic reports
- automatic deletion of tasks (Net8).

All theoreticians agree that in the field of military technology, this revolutionary technology has enormous potential, and the development of field artillery systems and procedures is no exception. And how does it do or facilitate all this? The following thoughts will be about this.

Intelligence and Artificial Intelligence

Emerging and disruptive technologies. It is a trendy term, or perhaps it is more accurate to say that it is a popular term, you can read it everywhere, and you can hear it at conferences, but to be honest, there is nothing new about it. In human history, it has happened countless times new technologies have completely changed people's everyday lives, causing warfare, and the success or failure of entire empires.

Without the need for completeness, I think it is enough to mention the difference between bronze and iron weapons, the appearance of chariots or firearms, machine guns,

the first use of airplanes or submarines, and to mention an example from the original topic of the article: the appearance of breech-loading guns. These new technologies revolutionized warfare for their time. After their appearance, nothing was the same on the battlefields as before.

But as is usually the case with such topics, it is almost impossible to find a unified concept.

The formulation of the European Union, in its simplicity, can be a useful help to understanding the idea: "Emerging Disruptive Technologies (EDTs) have the potential to revolutionize warfare." (Net6).

If we try to identify the areas that revolutionary technologies contain, we also do not find a unified approach, but usually, 7-9 areas are distinguished in the literature. Here is a list from NATO's official website:

- artificial intelligence
- autonomous systems
- quantum technologies
- biotechnologies and human development
- hypersonic systems
- space
- Innovative materials and production
- new energy
- next generation communication networks (Net2).

The technologies that fit into the categories listed above can therefore change the world,

the warfare, and consequently also the operation of NATO. NATO's latest Strategic Concept for 2022 draws attention to the fact that these represent a huge opportunity, but also contain risks (Net1). That is why the Alliance works with its partners in the public and private sectors, academic life, and civil society to develop and apply new technologies, define international principles of responsible use, and thus maintain NATO's technological advantage.

Now let's look at artificial intelligence, and first of all intelligence itself. Well, there is not really a universally accepted definition. According to David Wechsler, "intelligence is a complex, global ability of an individual that allows him to act purposefully, think rationally and deal effectively with his environment (Réthy, 2004)." (Net1). According to another, somewhat more complex concept: "Intelligence is a general mental ability that includes reasoning, planning, problem-solving, abstract thinking, understanding complex ideas, quick learning, and the ability to learn from experience." (Net1).

Artificial intelligence must therefore comply with what is described in the previous concepts; it has (he/she?) to be able to draw conclusions, solve problems, be able to think abstractly, and understand complex ideas. And finally, the most important idea from the point of view of our study, is able to learn with the help of their experiences. According to the literature, the following three levels of the topic are currently distinguished:

- ANI (Artificial Narrow Intelligence) is the name given to the initial, goal-

oriented systems used today. These learn from experience, and detect and predict patterns, but are not yet "real minds", with the ability to recognize faces, operate self-driving cars, etc. limited. These can be more like test sub-jects for later, more complex systems.

- AGI (Artificial General Intelligence) will be able to perform intellectual tasks that only humans can do today. These systems will be able to go one step further and will be able to formulate abstract thoughts, ones that do not necessarily follow from their experiences.
- ASI (Artificial Super Intelligence) will have human capabilities, but all of them will be much better than humans, processing and analyzing information much faster and more accurately than we do. Perhaps it will make the man himself obsolete... (Net4)

After some of the thoughts discussed above, let's examine how AI can help the development of field artillery, or more precisely, the development of artillery tools and subsystems...

Artillery Reconnaissance and Target Acquisition

The appearance of indirect fire, notably when the target was no longer visible from the firing position, also brought with it the development of artillery reconnaissance. From the very beginning, the artillery profession has strived to continuously develop the

various procedures, tools, and instruments of specialist reconnaissance. However, from the 1860s to the present day, whether we are thinking of conducting reconnaissance or collecting and analyzing incoming data, the system has been built on humans, generally more educated than average, and trained over a long period of time as an artillery soldier.

However, in the reconnaissance system, this more educated and better trained person is in many cases a passive observer of the events on the battlefield for hours or even days.

Due to the complexity of the professional work, certain squad leader positions were filled by officers or ensigns in artillery reconnaissance companies, during World War I and II.

This otherwise very important task was performed and is still performed today so that at the end of a well-developed process, the artillery can effectively destroy its targets and provide reconnaissance information to the commanders of maneuver forces. However, with the spread of artificial intelligence, this may fundamentally change, as it can provide significant assistance to humans in most of the components of artillery reconnaissance, and can even take over some of the tasks. Since these systems are unlikely to tire, they are more suitable for monitoring a part of the battlefield for hours or even days, for example. During their activity, instead of getting tired, they learn with the help of their

own experience, so their efficiency and accuracy increase, and thus the effectiveness of artillery reconnaissance increases overall.

Artillery reconnaissance systems are actually capable of two types of “detection”. The most common is visual information, whether it comes from observation points on the ground or from drones. Then the artillery forward observer actually sees the information that the elements of the system, such as an optical instrument, deliver to him. AI-supported systems (Figure 1), with the help of computer vision, are not only able to detect targets, but also to interpret them and, if necessary, make decisions. Artillery reconnaissance, however, also relies on a non-negligible amount of technical reconnaissance data (from moving target locating radars, counter-battery radars, and sound ranging systems), which are “only” numbers compared to visual information. In this case, the person does not see the image itself but only infers the reality based on numbers.

Figure 1. HattoriX AI Enabled Target Acquisition System



In both cases, the AI can provide enormous help to the artillery soldiers who collect and process reconnaissance data. On the one hand, they deal with a much larger amount of data at a given time than they do, and on the other hand, thanks to their learning ability, it would be able to recognize and identify natural and artificial landmarks, complex battle formations and targets much faster and more reliably, even in the case of finding their small details, or even maneuvers, which are important for artillery reconnaissance. Evaluation systems operating in this way would be able to filter out deceptive goals with greater certainty and predict the future activities of the opposing party based on the conclusions drawn from doctrinal principles and past “combat” experiences.

Support for the Combat and Fire Direction System

We examined the issue of artillery reconnaissance first since everything starts with that. Without adequate quantity and quality of reconnaissance information, the artillery is unable to carry out its activities effectively. However, if the reconnaissance system works properly, then the artillery's combat control and, within that, the fire control system will have a huge amount of data and usually of adequate quality to fight the battle successfully. It is not easy to manage this enormous amount of data, and it is almost impossible to analyze it and draw timely conclusions since we must remember that most of these activities take place at the tactical level, where

the time factor is of paramount importance and usually there is never enough available...

The calculation procedures, and finally the fire control systems, started to develop due to the appearance of indirect fire, but initially, they were primarily limited to the calculation of firing elements. With the development of technology, this process was taken over by programmable calculators and later by computers while nowadays the entire process can be automated. Nowadays, in addition to technical fire control, the systems are able to perform most part of the tactical fire control without human intervention.

However, even today, the key to the field artillery's combat control systems is the human. Many functions in the decision-making process are still performed by skilled artillery gunners. As part of artificial intelligence, machine learning algorithms can analyze a huge amount of historical data, identify patterns, and with the help of predictive analytics, predict future activities, thereby making them more usable, easier to interpret for the decision maker, and able to provide better-developed suggestions.

Accurately predicting the enemy's future activities provides a huge advantage to decision-makers of all levels and professions. Of course, this is no different for field artillery. Knowing in advance and, as accurately as possible, where the enemy will move or where he will be and what he will do means that the artillery reconnaissance forces are better able to focus their efforts on given areas or activities, which ultimately results in a more accurate fire plan and more precise

distribution of forces. It will result in faster and more efficient maneuvers and fire missions in firing position... Probably with much less ammunition usage.

In this way, if the decision-making process as a whole is not yet automatic, perhaps it never will be, but they are able to take part of the burden off the shoulders of the commander, allowing the person to deal with other important issues. A huge advantage of using AI is that the system can easily create harmony between the purpose of the fire mission (in a fire mission, this may be the desired level of destruction) and all the circumstances of its execution. For example, these circumstances can be without the need of completeness: the terrain and weather conditions, the activity (counteractivity) of the enemy, its possible expected movement; possible fire units and firing positions, types of ammunition to be used, and many more similar factors. Thus, the proposal will be born after evaluating many more factors than if it were done by the human mind, reducing the time of the entire process of destruction, but increasing its accuracy and effectiveness, and can drastically reduce the amount of collateral damage.

Autonomous Weapons

I believe that field artillery will not change significantly in the future, and in most armed forces it will consist of mortars, towed and self-propelled guns, MLRSs, and tactical missiles.

Figure 2: Archer Artillery System



Thanks to military-industrial developments, new technologies, and the materials used, the weight of weapons will be reduced to a great extent, by up to 25-50%, but a 30-40% increase in their firing range can be predicted. Wheeled self-propelled guns that are lighter than the current ones and capable of maneuvers performed with rapid movement, with smaller crews, will come to the fore.

For example, among the many Western self-propelled guns used by the artillery of the Ukrainian armed forces, the most popular is the French CAESAR gun, which, although less armored than its counterparts, is much more mobile than them due to its 17 tons. Thanks to this mobility, against an average loss of 30%, the French gun is permanently around 10%...

More and more manufacturers will strive to create the ability to fire from the movement in field artillery as well. Based on all this, we could judge that in the future, due to the increase in the capabilities of the field artillery, the number of their organizations (units, guns) will decrease, even drastically. But, for example, the UKR-RUS war shows the exact opposite, since before the war a Russian infantry brigade had 4 artillery battalions, the battles in the Donbas showed that the Russian forces tried to combine 80-90 field artillery weapons for artillery support of each maneuver brigade, on the model of the previous artillery groups.

The mentioned changes are actually traditional, but the EDTs can also bring changes that the gunners would not have dared to think about before. Such a “non-traditional” change could be the emergence of autonomous (weapon)systems. The demand for the use of this kind of weapon system is not new, since it is a completely natural need to replace those functions on the battlefield that do not necessarily require the presence of the creative human mind with machines. A crew of a gun or persons on an artillery observation post actually work according to specific schemes or “checklists”. In certain situations, they perform certain tasks, it is relatively rare that these people have to invent something completely new or implement something completely new on the battlefield. It would be easy to say that these tasks can be performed by a machine. However, this need could only be met minimally before our time,

as we did not have the appropriate technology.

Today, however, the situation has changed. More and more self-propelled gun turrets are unmanned, and for example, a self-propelled anti-ship missile launcher appeared in the United States Marine Corps, which no longer has a crew at all. The crew of the RCH 155 gun is already only 2 people, but the manufacturer plans to operate the combat vehicle by remote control, so without a human crew...

Figure 3. NMESIS



Figure 4. RCH 155



However, this not only relieves a person of certain dangerous, difficult, nerve-racking, or boring jobs but can also greatly increase the effectiveness of the gun by making the gun perform its tasks faster and more accurately.

Just think of the time it takes to load guns with human power and the use of automatic loading equipment. Not to mention that, unlike humans, machines don't get tired...

Here, I am not only referring to the human effort already mentioned in the previous point and the resulting possible inaccuracies, but also to the speed of independent decision-making, the amount of information prior to decision-making, etc.

During the combat activities of nowadays, the rapid movement of troops and the continuous artillery support of our own fast-moving combat troops are of particular importance. The experiences of the UKR-RUS war clearly prove that the field artillery can also provide this support with continuous movement in such a way as not to endanger its own survivability to a greater extent than necessary.

According to the practical experience of the Ukrainian artillery, fire units

must not spend more than 5 minutes between leaving the covered place and reoccupying it, and cannot spend more than 3.5 minutes in a firing position. The length of a fire mission carried out from a firing position cannot be more than 1-2 minutes. If the time is not enough to achieve the desired level of destruction, then for the same purpose, they will perform another fire mission from a different firing position, but they will not stay in the old one.

Ammunition

When we talk about the possible use of artificial intelligence, most of us think of spectacular robots or wall-filling 3D real-time images that help commanders make decisions. In reality, however, this revolutionary technology will probably appear and spread in a less “spectacular” way. For example, new types of ammunition are fired from completely traditional artillery weapons that have been used for decades.

A good example of this for US artillery is the C-DAEM ammunition currently being developed by the Raytheon company, which will probably replace the DPICM shell, which was regulated in the 1980s and was also revolutionary in its time (Net7).

Dual Purpose Improved Conventional Munition – these were actually cluster

projectiles that, when fired over a specific target area, exploded into countless sub-charges roughly the size of tennis balls, which then sought out individual armored targets. These, attacked from above, were quite effective means of destruction.

The task of the new GPS-controlled type will be similar but with the help of AI. As a result, according to the manufacturer, with a firing range of approximately 60 km, it will be able to scan an area of approximately 28 km² and find its target by recognizing, evaluating, and, if necessary, prioritizing the objects that have been detected. The first versions will probably be effective against tanks and armored vehicles, but the next step in further development will be the creation of even more sensitive ammunition, which will be effective against smaller targets, notably guns, and smaller vehicles or even individuals. Building primarily on the experiences of the UKR-RUS war, the manufacturer is trying to solve the problem of using GPS without assistance, presumably relying on image recognition (Net3).

At first reading, the described may not even seem special, since newer and newer ammunitions have always been developed over time, obviously, this is just one of the series... but no. Thanks to AI, after firing, this type of ammunition does not hit a specific target area or target and exert some effect but instead searches for the target or targets that have been designated for it within a certain area. It

goes without saying that the accuracy of this ammunition far exceeds that of its predecessors, making them far more effective. However, an important circumstance is that with the application of AI, the level of collateral damage can also be greatly reduced.

The next step will be the use of AI-supported loitering ammunition fired by artillery guns or MLRS. Its operation is similar to the ones discussed above, with the non-negligible difference that, after being fired over an area, the ammunition can “wait” for a certain period of time and conduct reconnaissance during this time. Based on their previous knowledge and acquired reconnaissance information, these types of ammos, evaluating the situation, choose not only their tasks but also the most suitable time and method of the strike. This will further increase efficiency and reduce the collateral damages as well.

And what happens next? Well, perhaps the many loitering munitions fired over a target area will be able to communicate with each other, they will be able to share their experiences with each other, thereby “helping” each other's activities, and distributing the targets among themselves, or coordinating the impact of several devices on one target at the same time. They will do all this without human intervention, but hopefully with human control...

Possible Problems

So far, the study has only talked about positive changes and benefits, but the possible negative sides of the theme should not be left

unmentioned either. Of course, as with any new technology, there are countless open or unsettled questions and it is certain that even more will arise in the future. However, some problematic areas are already emerging. When we talk about negatives, we should not specifically examine the relationship between artillery and AI, but now in an even broader perspective, AI itself and its application in the armed forces.

First, AI-supported systems are capable of learning, but the algorithms must rely on accurate and reliable data to do their job properly, which requires advanced and widespread communication systems.

This also raises another issue, the paramount importance of ensuring cyber security and information security, so that the principle of "accurate and reliable data input" is not violated due to possible malicious manipulation or computer attacks, because this can greatly reduce the effective use of the systems.

Finally, it is worth mentioning a problem that is one of the biggest questions in the undeveloped area. The dynamics of AI-supported warfare will probably be so fast that it already exceeds "traditional" human decision-making processes, so it could easily be that the system that is supposed to help them actually makes human intervention almost impossible. The consequences of this are still unforeseeable today.

Ethical Considerations

In addition to the technical challenges, however, it is worth mentioning a much

bigger problem, the lack of clarity of ethical issues. Today it can be said that there is actually no AI conference in the world, not a single article is published that does not deal with this topic. Experts agree that it is fundamentally problematic to put the question of the decision to destroy in the "hands" of a non-human, albeit human-created, intelligence, but they also agree that the question promises too much profit to not deal with it (Net5).

Nowadays, the responsibility of AI-supported systems appears most seriously in healthcare and warfare. During the medical malpractice lawsuits that have taken place so far, the courts have generally taken the position that AI should be understood as medical textbooks and that it is actually the doctors' responsibility to make their decisions based on what they have learned (Négyesi, 2022).

Along this logic, we could easily say that military leaders also study regulations, various manuals, and other documents, acquire the knowledge necessary for leadership, and make their decisions based on it. We solved the problem. But have we really solved it? Examining the armed struggles of written history so far, the answer is definitely yes. However, the situation is changing these days. AI-supported systems not only detect, collect, and recognize stimuli from the environment, and then give some kind of response as a result of them, but they are also capable of learning. So, they change. And this change is unpredictable, so the commander cannot

accurately foresee all the details of the future use of weapons...

The other reason why we have to deal with the issue is the opposing party. It is possible that when the bows appeared, there was a general who disliked them, and did not agree with their use, but if he did not protect himself against their effects in various ways, sooner or later he was defeated in the fight. The theorists of the time also debated a lot about the usefulness of the tanks and airplanes that appeared in World War I, but they had to solve the defense against them since they could not discuss the effects of the new devices. Countless similar examples could be mentioned for this as well, but also for when one of the warring parties did not want to accept the changes that had started in warfare. And the result of this was almost always collapse.

So, we can only do one thing. We acknowledge that this topic must be dealt with and that we lay down the universal rules as quickly as possible, which are meant to promote the regulation of the issue and create the conditions under which the rules can be observed. Otherwise, there is a high chance that the forecast mentioned in the introduction, referring to the situation 30 years later, will come true, or that we will start a possible armed conflict with an irreconcilable disadvantage...

Summary

After the first couple of decades of the appearance of field artillery, it played a central

role in all armed forces, and it still plays a central role now and in the foreseeable future. During the developments of the past centuries, the opposing parties have always tried to get the better of the other in a traditional way. They tried to develop guns with a longer firing range and a larger caliber. This type of traditional competition will probably remain in the future, but with the advent of AI, serious development will be experienced in other areas as well. This will play an increasingly important role due to the specifics of future warfare.

AI provides unprecedented opportunities in the development of subsystems of field artillery, since by utilizing its analytical ability and calculation speed, field artillery can increase its reconnaissance capacity, its fire control speed and accuracy, as well as the speed of decision-making in general. Thanks to the new abilities, the speed and surprise of fires and movements can, together with greater effective-ness, provide a serious advantage on the battlefield.

I don't think it's worth debating whether it's permissible to carry out these kinds of developments, or whether it's permissible to use AI, because if we limit our own innovation due to certain ethical considerations, we can easily be at a competitive disadvantage against those forces that don't have with such restrictions. Instead, during the development and application of the various subsystems of field artillery with AI, special attention should be paid to handling the ethical aspect of the topic, and to ensuring the responsible and ethical use of AI. If we don't do it this way, it

is easy for our “negligence” to cause bigger problems in the future than the results we can achieve with the development.

The development of this revolutionary technology and its integration into field artillery development will undoubtedly define the future of armed conflict in land operations.

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