There is much debate about how technology such as autonomous systems, artificial intelligence, big data, blockchain and quantum computing, will define the character of the next war: to what extent is this proposition true? Discuss how these technologies will interact in any meaningful way, particularly with regard to the challenges of effective integration with existing systems and network architectures, and what the impact will be on military command and control. resource management and utilisation.

2Lt Almasi*

6 October 2019

Abstract

The pivotal role of technology on the battlefield is unquestionable and has been clearly understood in the past, however, as technology takes more of an abstract form, the implications become far more complex, too. The technologies that are under consideration here are AI, big data, blockchain, Internet of Things (IoT) and quantum computing - these abstract technologies are emerging fast and it is important for us to understand their implications from a military perspective. In this paper we discuss each of the above technologies and give examples of their applications. We believe that they mostly impact decision making processes and logistic systems; therefore, we applied this to the combat estimate or the 7 question and tried to understand how, in the future, softwares and machines can aid a commander in decision making. We find that that the 7 questions can be treated as an algorithm and its output is merely as good as its input and the processing of those inputs. Moreover, we detail how AI can be used to deduce meaning from big data sources, e.g. analysing imagery or how blockchain can be used to create a secure identity system not only for personnel but also machines and serialised items.

1 Introduction

Technology has always impacted how and why wars were conducted, take the first use of powered aircrafts for example in 1911 by the Italians against the Turks in North Africa (near Tripoli) [1]; where some claim that the tech and the advantage it provided led to the war or at the very least encouraged it.

In this paper we will explore the current emerging technologies of Artificial Intelligence, Blockchain, Big data, Quantum Computing and IoT (internet of things) devices in the context of warfare. We will explain why they will have an impact on future operations and furthermore explain how they will do so through examples. However, we can write thousands of pages about each technology, so we will therefore focus on one aspect and that is how these technologies will assist in decision making and resource management, and relating it back to the military's system, we will use the 7 questions (combat estimate) to develop a focused narrative. This in itself showcases that these technologies go beyond weapon systems and striking capabilities.

We note that the Ministry of Defence's own think tank [4] has published reports on the use cases of some of these emerging technologies, e.g. [8].

1.1 7 Questions (Combat estimate)

We believe that the technologies under consideration mainly assist in decision making processes and in management of resources. The combat estimate or the seven questions is the tool used to formalise planning and it is the process of making a decision, so, we think these technologies can fully or partially automate the combat estimate. But before we delve deeper into that, we should note that the combat estimate is an algorithm designed to aid the commander in making a decision – given the seven questions (the algorithm) and similar inputs (as each one of us is bound to interpret certain information differently) most commanders would reach the same if not very similar outcomes.

*Troop Commander at 71 Sig Regt, 31 Sqn, J Troop.

A good decision therefore we can argue to be one that had *good* inputs into the combat estimate, e.g. inputting the wrong data into the human terrain part in Q1 can potentially lead to lets say civilian casualties which can have various negative consequences. Figure 1 visualises how we can think of each question as a function or some algorithm that takes a set of input and gives a useful output which can feed directly into another algorithm, e.g. Q2 of the combat estimate.

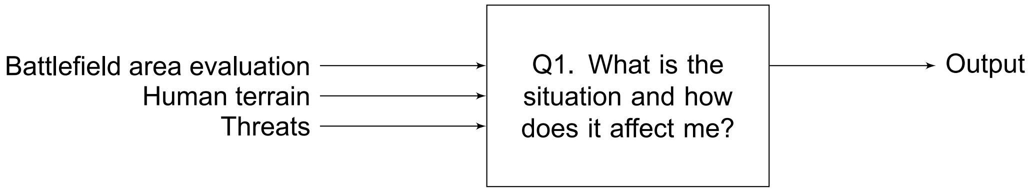


Figure 1: We can think of the 7 questions as an algorithm where it is given a set of inputs and it gives us a useful output.

So what makes a good output or set of orders? We can use the V's typically associated with big data [10] to do this.

1. **Velocity:** The speed at which the output is received, which would then include the speed at which data is gathered and thus processed within the combat estimate.
2. **Veracity:** The accuracy of the input data and also accuracy of how the data is interpreted.
3. **Variety:** Are we capturing all the available data from all the available sources?
4. **Volume:** Gathering small amount of data will probably lead to a less convincing outcome, however, in the real world it is about a comprise between speed and detail.
5. **Value:** Given the context, some information will be more valuable than others, thus certain information have will have bigger weighting on the final outcome.

Now we have taken the combat estimate and transformed it into some algorithm and have given it bounds we can now delve into the technologies under consideration to determine how they can each help reinforce the combat estimate either by helping to provide inputs or actually answer the question itself, the result of which can be a direct order or a recommendation.

2 Artificial Intelligence

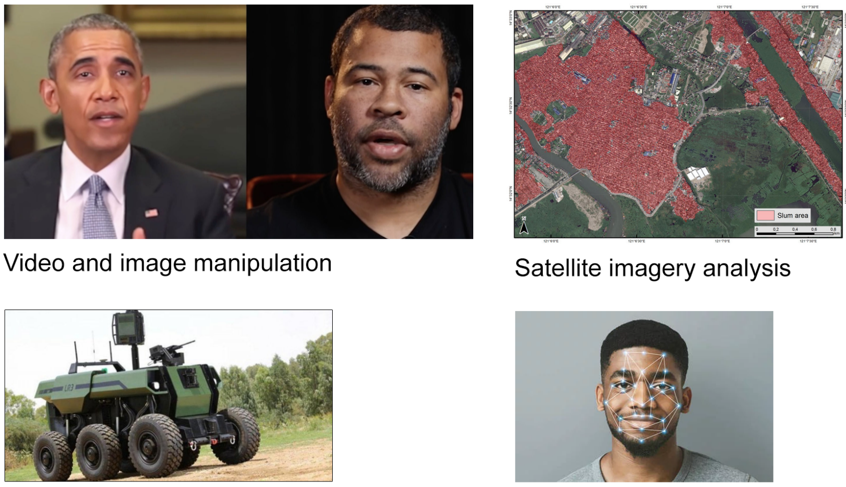
The general impact of artificial intelligence on the battlefield of the future is merely bounded by our imagination, laws, and ethical standards. Questions of whether we should limit the us of AI in the battlefield is very current, giving intelligent machines the authority to make decisions on whether to kill or not to kill is very much an open question, nevertheless we should develop or have knowledge of it to be able to counter it as other countries might have different views. Take China for example which is heavily investing in AI [2] with unknown intents and limited ethical boundaries.

Machine learning is in full use today, prominent use cases are DeepFake[1] videos - this is where a fake videos are created with almost realistic looking movement and speeches, the most well known example is the video of Obama created to give a speech that he never did in real life, figure 2 shows an actor (right picture) that read a speech and the Obama video consequently manipulated to look and sound like it was a real speech. Figure 2 provides some visual examples of use cases. This field is very active, there are studies on how to counter DeepFake videos such as [7]. Studies such as this [3] can be consulted to find out more about misinformation tactics.

2.1 Satellite imagery analysis

A clear use of machine learning is for satellite imagery analysis. DSTL[2] ran an open competition with prizes worth up to £100,000 [5] which encouraged people to participate in trying to identity roads, buildings, rivers and other features from an image captured by a satellite or a low flying aircraft. This is

[1] See examples here: `https://www.youtube.com/watch?v=-QvIX3cY4lc`
[2] Defence Science and Technology Laboratory



Video and image manipulation

Satellite imagery analysis

Self driving vehicle

Facial recognition

Figure 2: Examples of how machine learning and AI techniques can be used for real life applications.

important because maps are not as up to date as a satellite image, and decoding a satellite image is time consuming and requires trained personnel.

3 Blockchain

Blockchain is a technology that underpins crypto-currencys or digital money such as Bitcoin [9]. They essentially allow for individuals to create and trade money electronically without a trusted third party such as your bank. It resembles a ledger or a database for which everyone agrees on its content. This is a novel technology because now we do not have to trust anyone, the security and trust of the system comes from the cryptography and thus the trusted mathematics behind it. Digital money is the prime application (bitcoin at time of writing has a market capitalisation of c.$147bn[3]) of the blockchain technology but as we shall see it has more important applications.

It is to be noted that blockchain is not a single technology but a unique combination of old and new tech, the general purpose of blockchain is to bring together the important fields of cryptography, peer-to-peer networks with consensus schemes that defends against malicious actors.

The applications are numerous, therefore, we are forced to focus and explain one in detail to fully comprehend and appreciate its usefulness.

3.1 Use case: Identity and logistics

We will go into logistics and supply chain management, however, let us first explain *identity* and why it will play an important role in our case study.

Identity plays a vital role in everyday life for us, as we interact with each other and various systems that require identification and authentication, e.g. going through a secure gate, registering your presence, signing for a weapon at the armoury, or signing in/out of a base. These examples all require a representation of your identity and a form of authentication (usually ones MOD card). Digitising identity we believe is the first step in ensuring that different systems are able to communicate with each other effectively - imagine that we can get our NHS records directly sent to the Army so that blood groups or vaccination records can easily be verified, this is what identity on blockchain will offer us, this is a new field however there is considerable research under way to materialise this dream e.g. [6]. Moreover, identity should not be limited to humans, we are to formalise identity so that humans, legal entities, machines and others can be represented on a network, meaning that when we have intelligent machines, they will have an equal identity or that serialised items could also have an identity and that their state is recorded at every point in time - the technology behind blockchain will ensure that these records are tamper proof and secure.

[3] https://coinmarketcap.com/coins

A promising field within blockchain is securing supply chains – the importance of the logistics and supply chain of a fighting force is undeniably important. To be able to create a transparent supply chain, that is secure not through mere trust but through cryptography and undeniable mathematics. If we are to provide an identity for our weapon systems for example, and have a system in place that will record location and ownership with respect to time then by definition we should be always aware of the state of our system and most importantly the state of the system is totally secure, meaning that if someone tries to manipulate the records then we will know about it.

4 Quantum advantage

Imagine that you are able to break crypto codes faster than any other super computer or all computers on earth put together, design new materials, or simulate the world around us on a computer. This will all be achievable with a quantum computer. Theoretically we know how to simulate a bouncing ball and a protein folding on itself, however there is a distinct differences between those examples, the computation required to simulate a bouncing ball is easy whilst a protein folding on itself is extremely expensive and simply to simulate a quantum behaviour it must be done on a quantum computer. Hence the need for such a device.

Although quantum computing is in its infancy, it is fast developing by industrial players such as Google and IBM and at a point where Quantum Advantage is reached – it will have consequences on secure communication and problems that usually require huge computational resources. We have proven that we can attempt to break public-key crypto-systems that use prime factorisation faster than algorithms that run on existing computers [12].

Quantum compass is another huge application of quantum machines, researchers at Imperial College London [11] are developing such capabilities, meaning that we can navigate without the use of satellites. Because GPS spoofing is a security problem, such quantum compasses can be used on drones to navigate around without the problem of getting hacked.

5 Revisiting the 7 questions

Now that we have gone through some of the technologies and have identified use cases, advantages and disadvantages, we will go back to our proposed use case in decision making processes (combat estimate) and resource management. Therefore, in this section we will bring the technologies together, explain how they will effect the battlefield and command & control.

These technologies go beyond conventional military technology as one would imagine, such as weapon systems and other striking capabilities. Here we have an opportunity to aid a commander in their decision making by offering much more data and evidence that can be used to come to a better decision. Moreover, the mass data will not overwhelm the commander but these same technologies can be used to recommend and even guide the commander in coming to a decision. Which raises the question of leadership, what is the role of leadership in the battlefield of the future. Do we have to start thinking about training our leaders in a different manner or perhaps a new human and machine leadership teaming?

To understand the implications of these technologies we have taken question one of the combat estimate and studied how the technologies can automate this single question. As we noted before the 7 questions can be thought of as an algorithm and plenty of research can be done to tailor this algorithm for a machine rather than a human commander. Figure 3 visualises a simple study on question one and we see how some of the technologies can be used to gather and process data from variety of sources.

Example of a process used to answer question on of the combat estimate:

1. **Data gathering:** Using sources such as battlefield and other sensors, satellite and other imagery, open source intelligence such as social media, human int and others we can create a large and up to date database of intelligence that can be accessed at any time. This is a big data solution.

2. **Processing:** e.g. we can use machine learning techniques to analyse a satellite image to identity enemy forces, equipment, terrain and much more.

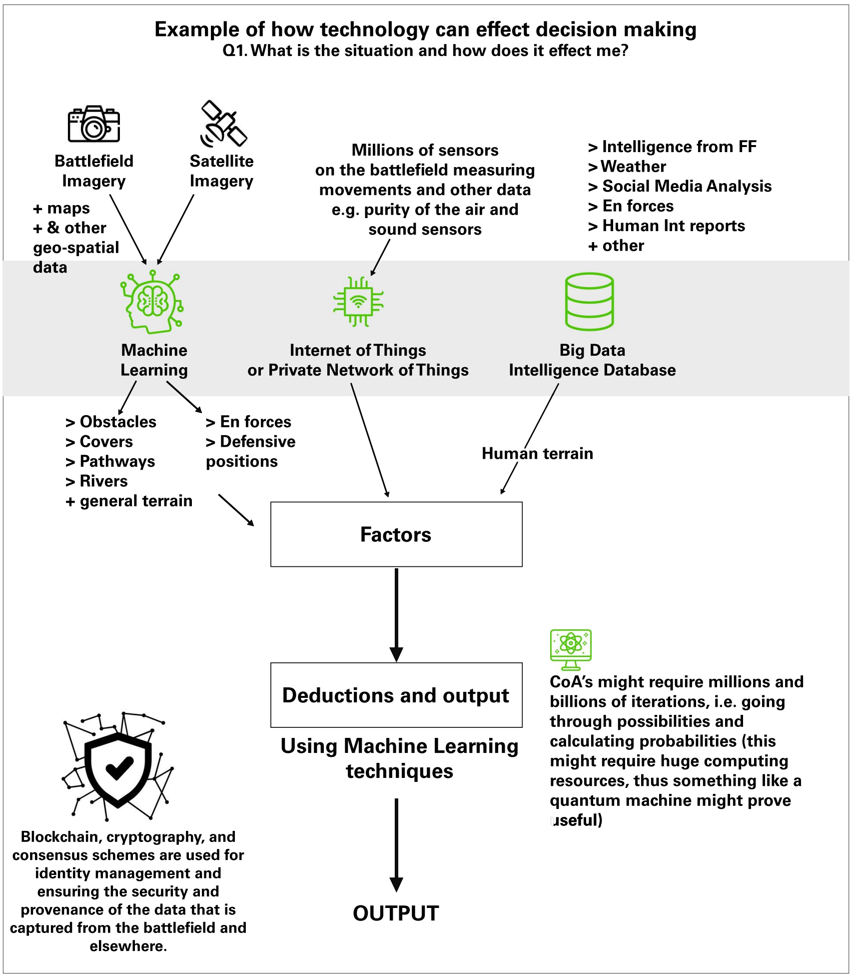


Figure 3: Diagram showing how we can think of the 7 questions as an algorithm - in this example we are using Q1 and showcasing how each of the technologies outlined in the previous sections can be used to automate the combat estimate or aid the commander in coming up with a desired output.

3. **Factors:** The output of the previous step can be used as a factor, e.g. identified two BTR-80 within area of operation - the system can pre-populate the factors with such information. Moreover, stronger algorithms can calculate the probability of its state and positioning.

4. **Deductions from factors:** Using machine learning techniques we can contextualise the information and offer recommendations to a commander.

5. **Outcomes from factors:** Last step can be a optimisation problem - where the algorithm would run numerous simulations to try and understand how the outcome of each factor relates to the other and thus come to a solution that will minimise negative outcomes for friendly forces. Thinking about a very complex battlefield, this might be time consuming on a traditional computer, whereas a quantum machine is ideal for this sort of task, thus it might prove useful.

So, we have taken these technologies and applied it to a decision making process, more behind the scene management rather than autonomous vehicles, killer robots and swarm of drones. Those are credible examples of applications, however, we believe they could have a bigger impact at a strategic level because together these technologies can gather more data and intelligence, process them and come to a conclusion faster, thus, it means we can think and act quicker than the enemy and always be ahead.

6 Conclusion

We briefly discussed that technology can be pivotal for the outcome of any campaign and moreover developing the capabilities at times of peace can act as a deterrent. The technologies under consideration were AI, blockchain, IoT, big data and quantum computing - we looked at each technology and gave examples of their civilian and military applications. However, to really pinpoint their use cases and integration within our existing systems we looked at how, together, they can bolster decision making processes and thus we focused on the 7 questions or the combat estimate. We believe that these technologies will have a bigger impact on resource management and on decision making processes, which is in contrast to what we often associate technology with in the military, that is weapon systems for example.

We detailed how the 7 questions (combat estimate) can be formalised as an algorithm and we can use these technologies to automate the combat estimate to a certain degree or at least provide recommendations to a commander. Although the 7 questions is designed for a human, we can tailor it so that it is more suitable for a machine. We used question one in the combat estimate to show how each of the technologies can be used to gather data, process the data, create meaningful deductions and therefore at the end create a recommendation or a set of outputs that can be used for the other questions. As an example, we saw how machine learning techniques can be used to analyse imagery data to understand terrain and enemy forces. Moreover, we described how blockchain can be used to create decentralised identities for people, machines and other entities - meaning that new and existing systems can always relate an action to a specific identity and most importantly the interaction is secure and tamper-proof and inherently it provides non-repudiation. Lastly, these technologies will aid the commander in making better decisions at a faster rate and assisting with the utilisation of resources with respect to some objective.

7 Appendices

A 7 Questions

1. What is the situation and how does it affect me?
2. What have I been told to do and why?
3. What effects do I need to achieve and what direction must I give to develop my plan?
4. Where can I best accomplish each action or effect?
5. What resources do I need to accomplish each action or effect?
6. When and where do the actions take place in relation to each other?
7. What control measures do I need to impose?

References

[1] *Air warfare*. en. URL: `https://www.britannica.com/topic/air-warfare` (visited on 10/03/2019).

[2] Christian Larson. *China's massive investment in artificial intelligence has an insidious downside*. en. Feb. 2018. URL: `https://www.sciencemag.org/news/2018/02/china-s-massive-investment-artificial-intelligence-has-insidious-downside` (visited on 10/04/2019).

[3] C. Day. "The Future of Misinformation". In: *Computing in Science Engineering* 21.1 (Jan. 2019), pp. 108–108. DOI: `10.1109/MCSE.2018.2874117`.

[4] *Development, Concepts and Doctrine Centre - GOV.UK*. URL: `https://www.gov.uk/government/groups/development-concepts-and-doctrine-centre` (visited on 10/06/2019).

[5] *Dstl Satellite Imagery Feature Detection*. en. URL: `https://kaggle.com/c/dstl-satellite-imagery-feature-detection` (visited on 10/04/2019).

[6] P. Dunphy and F. A. P. Petitcolas. "A First Look at Identity Management Schemes on the Blockchain". In: *IEEE Security Privacy* 16.4 (July 2018), pp. 20–29. ISSN: 1540-7993. DOI: 10.1109/MSP.2018.3111247.

[7] D. Güera and E. J. Delp. "Deepfake Video Detection Using Recurrent Neural Networks". In: *2018 15th IEEE International Conference on Advanced Video and Signal Based Surveillance (AVSS)*. Nov. 2018, pp. 1–6. DOI: 10.1109/AVSS.2018.8639163.

[8] *Human-machine teaming (JCN 1/18) - GOV.UK*. URL: https://www.gov.uk/government/publications/human-machine-teaming-jcn-118 (visited on 10/06/2019).

[9] Satoshi Nakamoto. "Bitcoin: A Peer-to-Peer Electronic Cash System". In: *Cryptography Mailing list at https://metzdowd.com* (Mar. 2009).

[10] R. Patgiri and A. Ahmed. "Big Data: The V's of the Game Changer Paradigm". In: *2016 IEEE 18th International Conference on High Performance Computing and Communications; IEEE 14th International Conference on Smart City; IEEE 2nd International Conference on Data Science and Systems (HPCC/SmartCity/DSS)*. Dec. 2016, pp. 17–24. DOI: 10.1109/HPCC-SmartCity-DSS.2016.0014.

[11] *Quantum 'compass' could allow navigation without relying on satellites | Imperial News | Imperial College London*. URL: https://www.imperial.ac.uk/news/188973/quantum-compass-could-allow-navigation-without/ (visited on 10/06/2019).

[12] Peter W. Shor. "Polynomial-Time Algorithms for Prime Factorization and Discrete Logarithms on a Quantum Computer". In: *SIAM Journal on Computing* 26.5 (Oct. 1997). arXiv: quant-ph/9508027, pp. 1484–1509. ISSN: 0097-5397, 1095-7111. DOI: 10.1137/S0097539795293172. URL: http://arxiv.org/abs/quant-ph/9508027 (visited on 10/04/2019).