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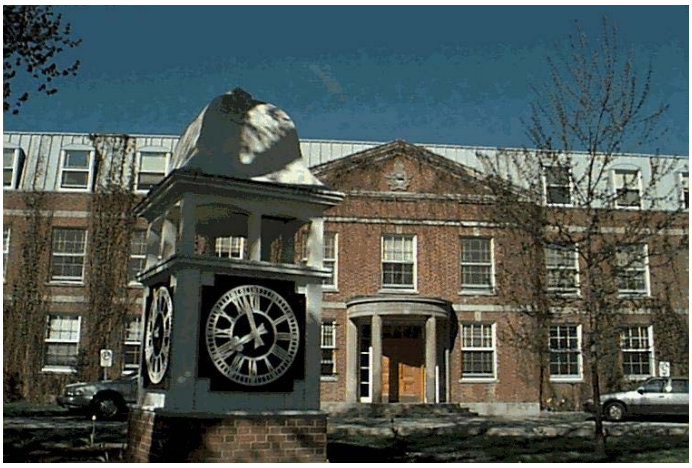

THE CHANGING NATURE OF WARFARE: ARTIFICIAL INTELLIGENCE AND ITS OPPORTUNITIES

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AIM

1. This paper is written in response to a question posed by the Canadian Armed Forces (CAF) Chief of Force Development (CFD) concerning the impact of transformative technologies (artificial intelligence, quantum computing, and autonomy) on the fundamental nature of military operations. As such, this paper aims to describe how artificial intelligence (AI) is shaping approaches to military technological advancements and how future developments within this field have the potential to change the overall character of warfare. This paper will not focus on a single element of the Canadian Armed Forces (CAF) but instead will provide a broad understanding as to how and where this emergent technology could be employed across multiple components over the immediate and future timeframes.

INTRODUCTION

2. Technological change within the military realm continues to advance at incredible rates, potentially changing how military forces and capabilities are structured and employed in future operations. It has been stated that "the military is on the cusp of a major technological revolution, in which warfare is conducted by unmanned and increasingly autonomous weapon systems."[1] An essential element of this technological revolution is the development and application of AI-driven technologies. There is no agreed upon of AI, however, for this paper AI is defined as "the ability of a digital computer or computer-controlled robot to perform tasks commonly associated with intelligence beings".[2] This definition, although broad, provides framing for why successful development and employment of AI in military operations will change the nature of warfare by enabling humans or even potentially replacing humans in some aspects of military operations.

3. Multiple critical factors drive the current emphasis on AI within military organizations. The operational environments in which military forces find themselves continue to increase in richness of data and information. The inability to efficiently process, exploit, and disseminate this information promptly is no longer possible solely through human effort which presents the risk of failing to enable informed decision making by military leaders. Operating with increased speed, accuracy, effectiveness, and lethality is critical current and future operating environments, elements to which AI offers enhancements. Also, rapid advancements on in civilian commercial and scientific industries have brought to the forefront the potential AI has to enhance multiple aspects of military operations. Finally, from a global perspective, both Russia and China are investing heavily in AI research and development (R&D). Both nations are applying resources to this domain to counter U.S. military global dominance. Given this fact, the U.S. Department of Defence (DoD) designed and implemented its Third Offset Strategy. [3] This strategy is intended to

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[1] Andrew Ilachinski, "Artificial Intelligence and Autonomy: Opportunities and Challenges." *Center for Naval Analysis* (October 2017): 1, http://www.dtic.mil/dtic/tr/fulltext/u2/1041749.pdf.

[2] Encyclopedia Britannica, s.v. "artificial intelligence" https://www.britannica.com/technology/artificial-intelligence

[3] George Galdorisi. "Designing Autonomous Systems for Warfighters: Keeping Humans in the Loop." *Small Wars Journal* (August 2016). 2, http://smallwarsjournal.com/jrnl/art/designing-autonomous-systems-for-

"maintain and extend United States competitive technological and operational advantage by identifying asymmetric advantages that are enabled by unique U.S. strengths and capabilities." [4] This strategy has shaped how the U.S. is approaching and preparing for the future operating environment and therefore directly influences the CAF as a Five-Eye partner nation.

4. This paper will contest that it is critical the CAF commence its advancements within this domain so that it can maintain pace with the evolution of military operations through the employment of AI. Although it is uncertain how far AI enabled technologies will advance over time, there are ample applications of AI within the "narrow AI" [5] field that the CAF should leverage immediately to maintain pace with the changing character of warfare. This paper will outline opportunities for how and where the CAF can employ AI to within current and future operating environment. To further frame the remainder of this paper, AI will be viewed "not as a weapon. Instead, AI, from a military perspective, is an enabler."[6] Application of AI in CAF operations will be addressed through the use of using the five operational functions of Command, Sense, Shield, Act, and Sustain.

DISCUSSION

5. **Command**. Speed and accuracy of decision making are central to the Command function. AI has the potential to strengthen the overall command function of military operations by increasing human-machine collaboration in both the planning and execution of military operations. Recent developments in the field of AI have proven that "machines have been able to complete complex tasks and match or exceed human performance."[7] AI's successful defeat of reigning world champion in Go[8] in 2016 speaks to the power of AI in the Command realm and the developing potential of AI neural networks (NN) to achieve decision superiority. An AI NN is defined as "a computer program that operates in a manner inspired by the natural neural network in the brain. The objective of such artificial neural networks is to perform such cognitive functions as problem-solving and machine learning."[9]

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warfighters-keeping-humans-in-the-loop. An "offset" strategy is an approach to military competition that seeks to asymmetrically compensate for a disadvantaged position.

[4] Ibid., 3.

[5] The Haque Centre for Strategic Studies. *Artificial Intelligence and the Future of Defense: Strategic Implications for Small and Medium Sized Force Providers* (The Netherlands: 2017), 30. Narrow AI is defined as "machine intelligence that equals or exceeds human intelligence for a specific task."

[6] Michael C. Horowitz. "The promise and peril of military applications of artificial intelligence." Last accessed 12 October 2018. 2, https://thebulletin.org/landing_article/the-promise-and-peril-of-military-applications-of-artificial-intelligence/.

[7] Larry Lewis. "Insights for the Third Offset: Addressing Challenges of Autonomy and Artificial Intelligence in Military Operations." *Center for Naval Analysis* (September 2017): 1, https://www.cna.org/cna_files/pdf/DRM-2017-U-016281-Final.pdf.

[8] Andrew Ilachinski. "Artificial Intelligence and Autonomy: Opportunities and Challenges." *Center for Naval Analysis* (October 2017): 2, http://www.dtic.mil/dtic/tr/fulltext/u2/1041749.pdf. Go is a board game that was invented in China more than 2500 years ago (making it the oldest board game in the world), and is played on a 19-by-19 grind onto which players alternate opponent's territory (which is secured, and pieces "captured", when a board position is surrounded by a given colour). The defeat of the world champion is considered a landmark event because the number of possible moves in Go is so vast that, by almost any measure in complexity, it vastly exceeds that of chess. Further, most AI experts believed that no AI would defeat even a high-ranking Go player for another 15-20 years.

[9] Encyclopedia Britannica, s.v. "neural network" https://www.britannica.com/technology/neural-network.

6. Critical to the employment of NNs is data concerning the specific application of AI is the availability of data sets upon which NNs can learn and train against.[10] Given the significant data holdings (doctrine, post-mission evaluations, intelligence repositories, etc.) concerning the potential actions and reactions of enemy forces globally, this information could be leveraged to train NNs to learn and anticipate potential enemy courses of actions (COAs) during not only the planning but throughout the operation if the sources of data continue to be updated appropriately. Again, the decision-making process in the future operating environment will require much greater speed; information and intelligence will need to be quickly gathered and assessed so that commanders can make the decisions at increasingly rapid rates. NNs will, if military, commercial, and scientific developments continue, allow the CAF's advantages in information superiority to overcome the limits of human cognitive abilities, establishing and sustaining decision advantage against hostile forces.

7. **Sense.** Militaries, the CAF included, are increasingly operating sensors across the battlefield ranging from space-based, aerial, ground-based, and underwater platforms. Each of these sensor systems can collect and disseminate vast amounts of data across the operating environment, so much so that the "vector, volume, velocity and ubiquity of data are disrupting traditional tools of national security policy, operations, and intelligence."[11] It is unlikely that the range of sensors collecting information across the operating environment will decrease, but will almost certainly increase in scope and scale. One of the most prolific sources of data and information at this time are Unmanned Aerial Vehicles (UAVs) due to their widespread employment. For example, "on one mission, an MQ-9 Reaper RPAS might collect the equivalent of up to 20 laptops' worth of data, which is transferred back to the operator for analysis over satellite links."[12]

8. This fact presents two distinct problems for the CAF. The first is the requirement for a globally deployable secure communications network capable of transferring captured data and information from the point of collection to the point of processing, exploitation, and dissemination (PED). Secondly, the amount of data and information presents a direct challenge to intelligence analysts' capacity to completing the PED process. There is currently simply too much data and insufficient time and resources to process it effectively to achieve maximum value of collect. AI algorithms specifically designed to categorize, evaluate, and rapidly interpret data in structured and unstructured data sets will enable intelligence analysts to increase efficiency in the assimilation and determination of the value of collected information within the operational theatre. This new process, driven by AI algorithms, will undoubtedly enable the decision making process of military commanders by providing them with the information and intelligence needed to make the best possible decision in what will no doubt be a fluid, fast-paced environment.

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[10] Andrew Ilachinski, "Artificial Intelligence and Autonomy: Opportunities and Challenges." *Center for Naval Analysis* (October 2017): 4, http://www.dtic.mil/dtic/tr/fulltext/u2/1041749.pdf.

[11] Courtney Weinbaum and John N.T. Shanahan. "Intelligence in a Data-Driven Age." *Joint Force Quarterly 90, 3rd Quarter* (July 2018): 4-9. 1, http://ndupress.ndu.edu/Media/News/News-Article-View/Article/1566262/intelligence-in-a-data-driven-age/.

[12] United Kingdom. House of Parliament – Parliamentary Office of Science and Technology. *Postnote: Automation in Military Operations,* (no. 511, October 2015), 2.

9. **Shield.** AI systems have a dominant role to play within cyber defence.[13] Cyber operations, both defensive and offensive, have elevated in importance over the past two decades as a result of the increasingly networked nature of modern militaries. Both state and non-state actors across the globe have placed increased emphasis on their ability to actively and passively influence and impact military operational networks both in theatres of operation and domestically. This has presented challenges to humans responsible for network security due to the multiple avenues of entry and exit into networks and the significant data flows throughout military networks.

10. AI systems "can play a powerful role in their 'native' environment – cyberspace."[14] The vastness of data flows and information passage across modern-day military networks is staggering and ultimately prohibits humans from accurately identifying and dealing with harmful cyber operations on networks. Machine learning algorithms employed on military networks in cyber defence role have advanced to a level where they are capable of identifying malicious interactions with networks that would otherwise be missed by traditional human-based security efforts. As an example, the Massachusetts Institute of Technology (MIT), in partnership with a startup cybersecurity company, constructed a machine learning system capable of reviewing and 3.6 billion lines of log files each day.[15] The success rate of this machine learning program to detect attacks on the network was a staggering 85% but even more impressive was the programs ability to learn and recognize patterns of attack and counter them in as they evolve in real time.[16] Acknowledging the current cyber environment and the potential vulnerabilities that exist add increased emphasis as to why the CAF to must employ AI entities on its networks to increase both the security and integrity of its vital military networks.

11. **Act.** Although the nature of warfare is anticipated to change in significant ways over the coming years and decades, one consistent factor will remain; soldiers will be present on the battlefield. The complexity of the operating environments will undoubtedly increase and the ability of soldiers to determine the difference between combatants and non-combatants will be a progressively more complicated endeavour. AI-driven systems in the form of wearable electronics and connected combat applications can better enable humans on the front line to perform better in combat.[17] Providing front line soldiers with real-time linguistic translators able to leverage existing language datasets will increase soldiers situational awareness and understanding when presented with multiple unfamiliar languages within the operating environment. Further, "assisted human operations"[18] of this nature has the potential to inform soldiers on the battlefield of threat or non-threat posture when interacting with their operational environment through the monitoring of verbal and non-verbal cues presented. In combination, these two examples of future AI based capabilities will allow soldiers engaged across the spectrum of conflict to more accurately assess their surroundings with greater speed and fidelity, allowing for their tactical effectiveness to increase significantly.

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[13] The Haque Centre for Strategic Studies. *Artificial Intelligence and the Future of Defense: Strategic Implications for Small and Medium Sized Force Providers* (The Netherlands: 2017), 87.

[14] Ibid.

[15] Ibid.

[16] Ibid.

[17] The Haque Centre for Strategic Studies. *Artificial Intelligence and the Future of Defense: Strategic Implications for Small and Medium Sized Force Providers* (The Netherlands: 2017), 85.

[18] Ibid.

12. AI presents another opportunity for the CAF in the form of algorithmic targeting or "automatic target recognition."[19] Machine learning enabled sensors connected to a distributed military network with either preprogrammed inputs or persistent access to databases outlining the characteristics and signatures of enemy targets can enable the identification of enemy elements within the area of operations. The processing of sensor data in combination with the understanding of an operational commander's high-payoff target (HPT), high-value target (HVT) lists, and operational priorities allow the machine learning algorithms to present targeting options to commanders. Upon evaluation of the information presented to the commander, he or she will be in an enhanced position from which to determine whether or not to strike that identified target, what the most appropriate assets should be employed to engage the target, and accurately determine risk to mission and risk to force. Also, automatic target recognition provides increased levels of clarity on the emerging situation, allowing commanders to make an informed decision at speed while reducing risk to civilians and his forces within the battlespace.

13. **Sustain.** Military logistics is arguably the most critical element of military operations since without an integrated logistics system from national to tactical levels, military operations are severely impacted or, in the worst case, cease entirely. The increased digitization of the CAF logistics supply system and the increased utilization of digital tracking methods in recent years has advanced the effectiveness and efficiency of the system, yet AI has the potential to further optimize its operations. AI algorithms such as those currently employed in the commercial sector offer significant benefits to military logistics. AI with the appropriate access to centralized databases could interrogate and study logistics requirements of military elements thereby potentially automating the prioritization and distribution of resources across the area of operations. It is likely that this increased automation through the use of AI will reduce the manpower required to operate the logistics system, providing a rebalancing of human capital needed to ensure operations are maintained.

CONCLUSION

14. This paper outlined the increasing importance of AI as a transformative technology in both current and future operating environments, as well as how continued development in this field has the potential to change the overall nature of warfare. Also addressed were the major critical factors driving militaries towards AI enhanced technologies. The factors were:

a. increasing data and information availability and its impact on the human ability to PED effectively for maximum value;

b. rapid developments of AI in advancements in civilian commercial and scientific industries their potential to enhance military effectiveness; and

c. the competition between the U.S., Russia, and China for AI superiority to offset their strengths and weaknesses in preparation for future conflict.

Finally, using the five operational functions of Command, Sense, Shield, Act, and Sustain, this paper presented opportunities for each function where the CAF should focus its initial efforts of integrating AI technology within the narrow AI field.

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[19] Ibid., 88.

15. It is clear that the future operating environment will significantly change and that AI technology will be an enabling function needed to operate at the speed and efficiency required to be successful. To remain relevant, effective, and lethal in the future operating environment the CAF must actively embrace the potential benefits AI technology present immediately or risk falling behind the advancing technology curve.

RECOMMENDATIONS

16. Immediately commence relationship building and direct linkages to commercial, scientific, and academic organizations employing and developing AI technologies. Leveraging existing knowledge and experience will accelerate the CAF's overall understanding of AI technologies while also allowing for continual evaluation of developments and their potential application to CAF operations.

17. Commence development of military expertise in the field of AI to ensure the CAF has the requisite understanding and technical skills needed to develop AI in support of CAF operations.

18. Initiate a Defence Research and Development (DRDC) research projects into how the Canadian Army, Royal Canadian Air Force, Royal Canadian Navy, and Special Operations Forces can improve AI integration in their current constructs, as well as how best to prepare for advancements in AI applications in the future.

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