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AI vs *Fingerspitzengefühl:* Can Artificial Intelligence Replace Human Instinct?

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INTRODUCTION

Artificial Intelligence (AI) has been one of the most common buzzwords in the technological industry, businesses and militaries over the last decade. But what does AI mean? What does it mean for the Canadian Armed Forces (CAF)? As AI is still in its infancy, they are different interpretations of AI. For some, AI is decades away as they envision complex cyborg or android machines able to reason like humans. For others, AI is present in our daily lives when using Facebook ©; where the company is tracking your online behaviour and customizing advertisements based on which posts you visited previously. This vast discrepancy in interpretation is partly due to the fact the definition is constantly evolving as computers are becoming more powerful and are able to perform more complex tasks. As computer software is able to learn and think on their own, the threshold of what we consider intelligent will rise higher over time[1].

As technology is evolving exponentially, it is imperative the CAF continues to research and learn to use these new technologies in order to remain relevant in the future. AI is only one of the elements that are currently changing our world. Some authors are describing these changes as the beginning of the Fourth Industrial Revolution. This revolution is also called *Industry 4.0* or the *Internet of Things(IoT)*. The IoT is used to

[1] Button, Robert W. "Artificial intelligence and the military." *RealClear Defence (Online)* (2017).

describe the exploitation of technology through the interconnectivity of multiple devices, and concepts such as cloud computing, exploitation of Big Data, and Deep Learning or Machine Learning[2].

As briefly explained above, AI is almost a limitless subject in terms of discussion. AI has great potential to be used in military conflicts of the future but it is too vast to explore all its aspects in this essay. This paper will explore the potential use of AI in a deployable Joint Task Force Headquarters (JTF HQ) over the next decade. It will attempt to uncover the potential use of AI in the decision-making process while exposing its limitations. It will argue the applications, especially in a tactical deployment, are still in its infancy and require more development.

This paper will first attempt to define AI and its corollary terms, then present a general overview of the cognitive hierarchy and its influence on the decision-making process; and finally, it will evaluate through examples how AI could be implemented in a JTF HQ.

WHAT IS ARTIFICIAL INTELLIGENCE IN A MILITARY CONTEXT

In order to assess if AI can replace human instinct in a military context, it is important to define what AI is. As described in the introduction, the definition of AI is consistently evolving and will continue to do so in the foreseeable future. The Department of National Defence (DND) defined AI as "the capability of a computer to perform such functions that are associated with human logic such as reasoning, learning,

[2] Lu, Yang. "Industry 4.0: A survey on technologies, applications and open research issues." *Journal of Industrial Information Integration* 6 (2017): 1-10.

and self-improvement."[3] Furthermore, the North Atlantic Treaty Organization (NATO) uses the following terminology, which the CAF ratified as well:

- An interdisciplinary field, usually regarded as a branch of computer science dealing with models and systems for the performance of functions generally associated with human intelligence, such as reasoning and learning.
- The capability of a functional unit to perform functions that are generally associated with human intelligence such as reasoning and learning.[4]

Beyond these accepted definitions within the Canadian military community, there exists a fair amount of literature on the definition of AI in general. They can be classified into four different approaches: systems that think like humans[5][6]; systems that think rationally[7][8]; systems that act like humans[9][10]; and systems that act rationally[11][12][13]. Generally speaking, we can then say that AI exhibits behavior that on the outside looks like it requires human intelligence or is capable of rationally solving complex problems including reacting to problems it encounters. Therefore, we can categorize AI systems as two main categories: AI that is thinking like us versus AI that is perceived from a human

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[3] Canada, Department of National Defence. DTB Record 1596 (01/04/2005). *Defence Terminology Database*, http://terminology.mil.ca, accessed 2 May 202.Website available on the Defence Intranet Network

[4] Ibid., DTB record 11571.

[5] Bellman, Richard. *An introduction to artificial intelligence: Can computers think?*. Thomson Course Technology, 1978.

[6] Haugeland, John. "Artificial intelligence: the very idea." (1985).

[7] Winston, Patrick H. "Learning new principles from precedents and exercises." *Artificial Intelligence* 19, no. 3 (1982): 321-350.

[8] Charniak, Eugene, and Drew McDermott. "Introduction to Artificial Intelligence. ADDISON." *Reading, MA* (1985).

[9] Kurzweil, Ray, Robert Richter, Ray Kurzweil, and Martin L. Schneider. *The age of intelligent machines*. Vol. 579. Cambridge: MIT press, 1990.

[10] Rich, Elaine, and Kevin Knight. "Artificial intelligence. 1991 McGraw-Hill."

[11] Luger, G. F., and W. A. Stubblefield. "Artificial intelligence: its roots and scope." *Artificial intelligence: structures and strategies for* (1993): 1-34.

[12] Poole, David, Alan Mackworth, and Randy Goebel. "Computational Intelligence." (1998).

[13] Nilsson, Nils J. *Artificial intelligence: a new synthesis*. Morgan Kaufmann, 1998.

point of view as acting like humans. It is obvious that once the technology of AI improves, it will transform dramatically how the CAF will conduct operations in the future. Now that we have a common understanding of AI, we need to comprehend how the military decision-making process works in order to assess if AI will be able to replace the process or at least some portions of it.

CAF OPERATIONAL PLANNING PROCESS (OPP)

The OPP is the process of choice of the CAF to plan and order joint operations[14]. It is important to note the OPP is a process that can be adapted to the situation especially when time is of the essence. The intent of the OPP is to guide commanders and staff that are working at the operational and strategic levels. It is designed to work in a deliberate fashion but it can be adapted for contingency operations. It allows the staff to use a logical step-by-step approach to aid the evaluation of factors affecting the operation; present commanders with different approaches to deal with the issue, also known as Courses of Action (COA) to reach the objective articulated in the Commander' planning guidance while presenting the level of risk associated with each COA; it allows the formulation of a plan and finally permit the re-evaluation of that plan if the situation change. The OPP's formal process is composed of five stages: Initiation, Orientation, Courses of Action Development, Plan Development and Plan Review. It is essential to understand the process can be abbreviated when it is necessary to act quickly. Certain portions can be shortened or replaced by Rapid Response Options; the commander can ask the staff to develop only one COA in preparation for the next phase of battle. Most of

[14] Canada, Department of National Defence, B-GJ-005-500/FP-000, *The Canadian Forces Operational Planning Process (OPP)*

the senior staff in a JTF HQ would have received training on how to perform OPP especially during Joint Command & Staff Course (JCSP) where a common method to perform OPP is taught. Generally speaking, any graduates from JCSP should be able to perform well even though some members have not been as exposed as others to the methodology. Once the process is understood, the typical officer should have enough time in the CAF to use their previous experiences to contribute positively to the process. Unfortunately, the amount of information that requires processing by the staff officer has increased exponentially as the traditional domains (Land, Air and Sea) are now augmented by new domains, Cyber and Space, unknown to militaries a few decades ago. The amount of data now being collected is immensely greater than before, thus increasing the size of JTF HQ, in terms of manpower, to analyze data from more complex environments which is leading to the creation of silos of expertise. The challenge of the Chief of Staff is to orchestrate all these efforts in a collaborative team where the sharing of information and knowledge is essential to make the right assessment for the Commander.

Can AI supplement the staff officer or at least assist a staff officer doing OPP? Most experienced staff officers will agree the amount of data incoming in a HQ is reaching the limit or going beyond the ability of the human brain to process. It will be useful to have AI systems that can as a minimum be able to assist the staff officers during the OPP. The key question is how can AI systems help them and in which stage of the OPP can it enable. The cognitive hierarchy theory is a model that explains how humans can learn and transform data into wisdom. In the next section we will explore this model to understand if an AI could replace or augment staff officers.

COGNITIVE HIERARCHY MODEL

In a military context, we can use the cognitive hierarchy model to describe how commanders and staff officers use data to transform it into wisdom or understanding (see figure 1 below). The model is also used outside the military and is known by a few different names depending on the context that is used. The literature in the education domain use the same process and is known as the Social Cognitive Theory of Learning[1516]. In computer engineering and computer science it is also known as the Information Ladder theory by Norman Longworth[17]. All these models have a four-step method to transform raw data into wisdom or understanding that can be used by a commander and staff to make the best decision on the battlefield. These steps are: Data, Information, Knowledge and finally Understanding or Wisdom.

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[15] Schunk, Dale H. "Social cognitive theory." (2012).

[16] Luszczynska, Aleksandra, and Ralf Schwarzer. "Social cognitive theory." *Predicting health behaviour* 2 (2005): 127-169.

[17] Longworth, Norman. *Lifelong learning in action: Transforming education in the 21st century*. Routledge, 2003.

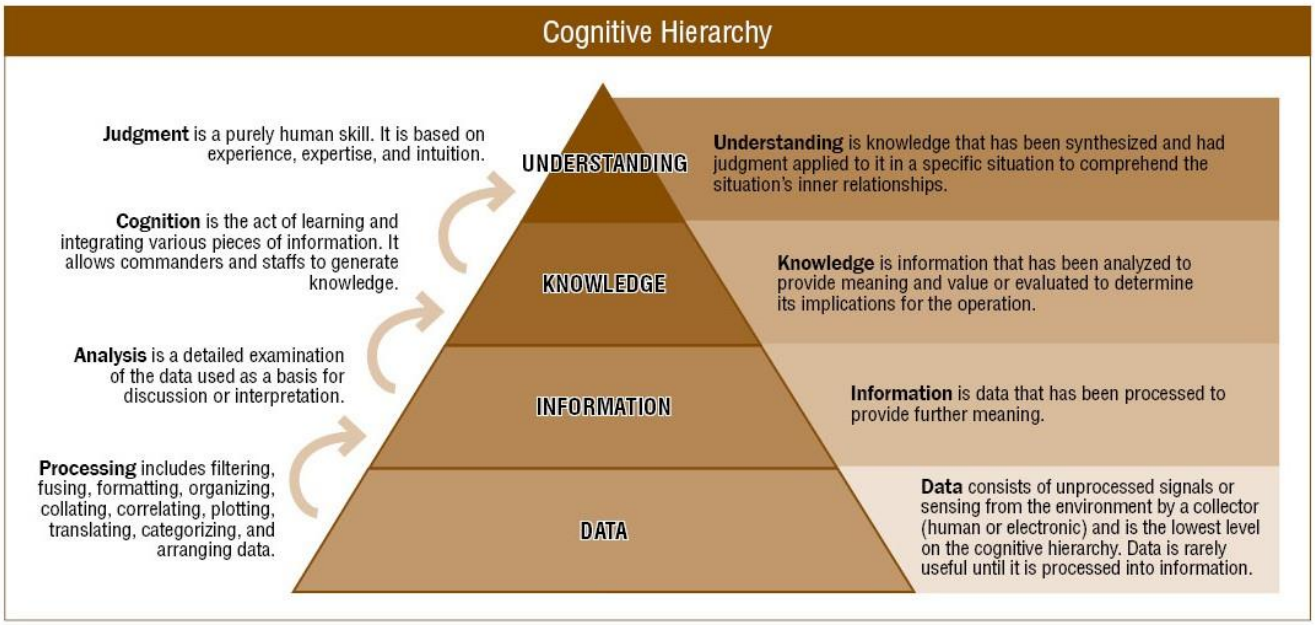

Figure 1 - Cognitive Hierarchy Model

Source: Bakke, Maj Peter C., Setting conditions to achieve effects for sustainment operations in *Army Sustainment Magazine*, Jan-Feb 2017

If we apply this model to a deployable JTF, we could say a video feed from a platform such as a land-based reconnaissance vehicle will fall under the Data Layer as the data is raw and has no significance[18]. In the case of a video feed from an Unmanned Aerial Vehicle (UAV) that includes the coordinates of the video feed and its timestamp, it is considered to belong to the Information Layer as the the data has been given a meaning by establishing a relationship between different elements of data (in this example, they are three elements: the video feed, the coordinates and the time). Once multiple pieces of information is analyzed, it becomes part of the Knowledge layer. The analysis of

[18] Canada, Department of National Defence, *Canadian Forces Joint Publication 6.0, Communication and Information Systems*, Working Draft 1.0

intelligence information on the enemy or the potential effects of the weather forecast on operations are examples in a deployed JTF HQ scenario. Finally, once we apply human judgment, we have reached the last layer called Understanding or Wisdom. When a commander decides on a specific COA during a Decision Brief, he must make a decision not only on the knowledge based on his staff analysis but also on his instinct which can not be quantified in a COA comparison matrix. Understanding is a unique human trait that traditional computers can not mimic.

The Cognitive Hierarchy Model is an essential tool for staff and commanders of a JTF HQ. In order to gain advantage against an adversary, the commander and staff must be able to shorten the amount of time it takes to transform data in wisdom. If this cycle is shorter than the enemy this should increase their chances immensely to be successful. The challenge remains that a commander must strike a balance between speed and the success rate of the decisions being made[19]. With the incredible amount of data entering a JTF HQ, it is easy to be distracted by a flood of irrelevant data. Commanders are often pressed for time as they are pulled in different types of backbriefs and engagement with partners which prevent them to fully assess all the information available in the HQ. The commander and staff risk to miss critical information when the quantity of data increase immensely, this increase of data inputs often lead to natural defence mechanisms[20]. One of these mechanism is called “bounded reality” where the commander and staff will

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[19] Curts, Raymond J., and Douglas E. Campbell. "Avoiding information overload through the understanding of OODA loops, a cognitive hierarchy and object-oriented analysis and design." *Annapolis, MD: C4ISR Cooperative Research Program (CCRP)* (2001). p. 3

[20] McKitrick, Jeffrey, James Blackwell, Fred Littlepage, George Kraus, Richard Blanchfield, and Dale Hill. "The revolution in military affairs." *Air War College Studies in National Security: Battlefield of the Future* 3 (1995): 65-97.

screen out new inputs and will continue to focus on a particular task[21] which can lead to ignoring critical information crucial to the outcome if it is presented too late. This could also lead to ignoring new information that would warrant the review of the plan which is the last step of the OPP that is often forgotten.[22]

WHERE CAN AI SYSTEMS BE EMPLOYED IN THE JTF HQ

So far this paper explored the definition of AI, described the CF OPP and briefly explored the cognitive hierarchy the commander and his staff must go through when analyzing plethora of data incoming into a HQ. This paper will now explore potential areas where AI systems could be deployed in the current environment. Where can AI be introduced in a deployed JTF HQ? What kind of job an AI can do instead of humans?

It is important to understand when and where an AI can replace a human to make the right decision. Figure 2 describes the stages of reasoning that a commander and staff must possess to be able to deal with decision-making scenarios that are gradually increasing in complexity[23]. Cummings adapted the Rasmussen's SRK (Skills, Rules and Knowledge-based behaviours) taxonomy and modified the model to represent its relationship with expertise and uncertainty.

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[21]Simon, Herbert A. *Administrative behavior*. Simon and Schuster, 2013.

[22] Curts and Campbell, Op. Cit., p. 4

[23] Cummings, Missy. *Artificial intelligence and the future of warfare*. London: Chatham House for the Royal Institute of International Affairs, 2017.

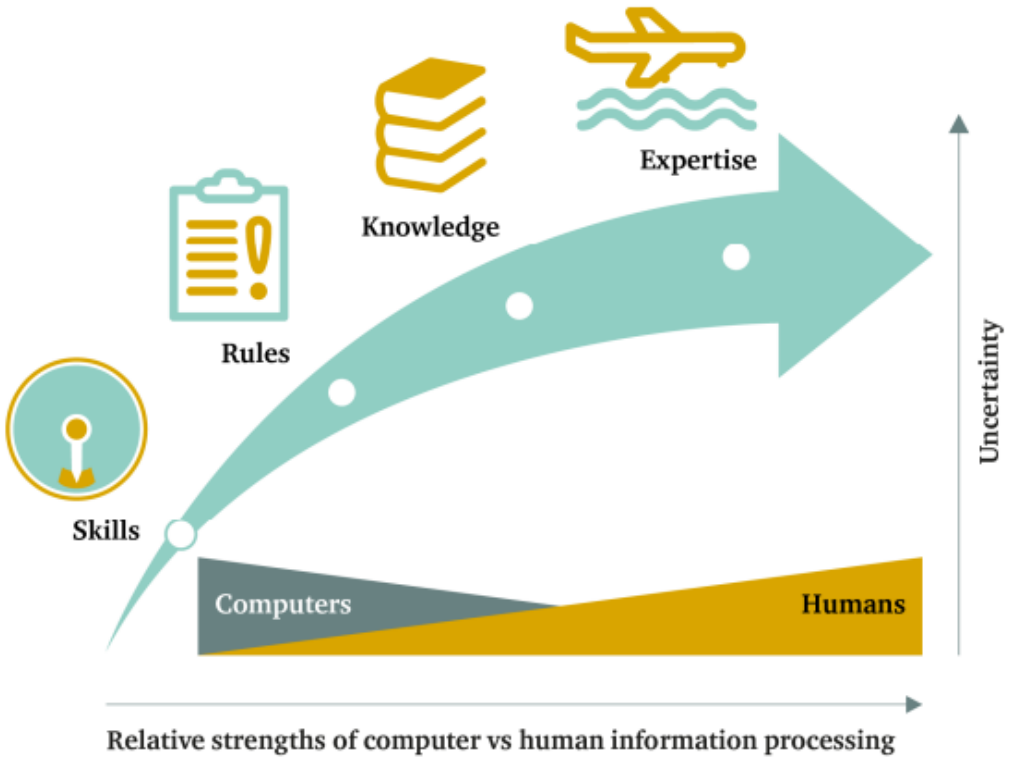

Figure 2 - Relationship between uncertainty and SRK and expert reasoning

Source: Cummings, Missy. *Artificial intelligence and the future of warfare*. London: Chatham House for the Royal Institute of International Affairs, 2017, p.5

The graph clearly demonstrates that computers or AI can perform discrete tasks that are highly probable easily while the human is outperforming them when the level of uncertainty is high. With the current technology in our AI systems, they are as good as we can teach them. It is important to note the Cognitive Hierarchy Model can be overlayed over this graph when reading it from left to right. It is evident that computers or AI excel at storing Data and Information however their performance decreases as we climb the Cognitive Hierarchy Model until an AI is no longer capable with today's technology to perform better than a human. For commanders and staff, the ability to deal

with complex situations with a high level of uncertainty is the flagship of an expert in their field however it is worth repeating these skills are extremely difficult for AI to replicate.[24]

Simple AI systems can be integrated in the JTF HQ over the next decade. These AI systems will be particularly useful in Stage 2 of the CF OPP. AI could filter raw Data and quickly and efficiently reached the Information level of the Cognitive Hierarchy Model. Currently, the network architecture of a deployed JTF is a combination of parallel systems where the information is formatted in a way that does not allow for an overall approach. As an example, space imagery has its own processor to filter the data and transform it into information and knowledge. If a CP-140 Aurora is observing the same area on the same day, the aircraft must send the imagery to a Deployable Mission Support Centre (DMSC) where it is transformed from Data into Information and Knowledge. This leads to human intervention to determine if the information presented is worth using. If all the data was travelling freely on a common architecture a powerful AI could do the processing of all incoming data in a centralized location. An AI system could be able to perform complex queries to filter the relevant data and elevate it to a higher level of the cognitive hierarchy model instead of processing more raw data in parallel. AI could easily fuse all the data which could provide invaluable input with the Intelligence Preparation of the Battlespace (IPB) and the COA development. A staff officer could task the AI to bring all the Intelligence, Surveillance and Reconnaissance (ISR) products from a specific grid square for analysis and task ISR assets to gather more information in the future.

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[24] Cummings, Op. Cit., p 5-6

Another example where AI can be used is the defence of the JTF HQ, if a sensor on a tower or tethered balloon was to detect suspicious movement in the vicinity, it could easily task a sensor with Infrared (IR) capability to confirm the activity. Ultimately, the AI could decide to engage the target if deemed hostile. Obviously, there is a significant ethical dilemma related to killing a human being without human validation of the threat but this is out of scope for this paper. These AI systems will be able to perform extremely well in the bottom levels of the cognitive hierarchy model but will AI be able to help at the higher levels over the next decade.

AI systems could be very useful during COA development and analysis. An AI could compute the COAs and run wargame for numerous iterations. This could give some insights on which COA has higher chance of success. Obviously, the aim of this AI will be to assist the commander and staff as an AI is currently unable to account for unpredictable human behavior however an AI could perform specific analysis of the impact of the terrain between the different COAs.

Some literature sees great potential for a subset of AI called Deep Learning to learn algorithms and enable themselves to automate the "complex representations without the human intervention"[25] This type of technology will not be ready over the next decade due to its very high complexity. Great military commanders have success often due to a combination of training, exercises, tactics but more importantly instinct. An AI could learn tactics of the enemy and study terrain to provide the most likely approach of the enemy force but how can it deal with human ingenuity and daring decisions? Just think

[25] Wiseman, Erica. 'Deep Learning for Human Decision Support' in *Strategic Technical Insights*. National Research Council Canada, 2017, p.5

of the story of the Trojan Horse in Greek mythology which is a very risky move from the Greek commander. Can an AI learn to be so out of the norm? Great military strategists such as Clausewitz, Liddel Hart and Erwin Rommel describe this gift with the terms *Coup d'oeil*[26] (literally quick glance) and *Fingerspitzengefühl*[27] (literally feeling with the tip of his fingers). These military terms recognize the ability of great commanders to assess complex situations and be able to quickly discern the wheat from the schaff. describe such ability.

The introduction of sophisticated AI is quite limited due to the stovepipe nature of the current network architecture of deployed JTF HQ. Once the architecture is improved and the processing of information can be done on one common platform, AI systems will become an essential tool to use to avoid data overload incoming from multiple domains.

[26] Brighton, Terry. *Masters of battle: Monty, Patton and Rommel at war*. Penguin UK, 2009. p. xvi
[27] Von Clausewitz, Carl. *On war*. Vol. 2. Jazzybee Verlag, 1956.p. 34

CONCLUSION

This paper defined AI and its corollary terms, then presented a general overview of the cognitive hierarchy and its influence on the decision-making process; and finally, it exposed some potential examples how AI could be implemented in a JTF HQ.

AI is almost a limitless subject in terms of discussion. AI has great potential to be used in military conflicts of the future. This paper explored the potential use of AI in a deployable Joint Task Force Headquarters (JTF HQ) over the next decade. It uncovered the potential use of AI in the decision-making process while exposing its limitations due to the current level of technological advancement. Its applications, especially in a tactical deployment, are still in its infancy and require more development.

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