Using Artificial Intelligence to Minimize Information Overload and Cognitive Biases in Military Intelligence

A Monograph

by

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Information overload and cognitive biases are two challenges analysts face in the quest to produce timely intelligence. In today's digital world, analysts have access to more information than their human brains can process. Analysts draw on their personal experiences, training, and intuition to interpret the meaning of information. Analysts' judgments are susceptible to cognitive bias that can skew the intelligence process. Leveraging artificial intelligence to process data and analyze information provides analysts more time to synthesize knowledge and build situational understanding of the operational environment. A scenario development methodology explores two common tasks intelligence analysts perform and explores opportunities for integrating artificial intelligence.
Machines can process data and analyze information quickly and indiscriminately. Analysts apply meaning to the patterns extrapolated by artificial intelligence and evaluate implications for the operations. The analysts' experiences, training and expertise, and knowledge of the mission help the analysts make determinations on how and why the information matters. Analysts incorporate

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Abstract

Using Artificial Intelligence to Minimize Information Overload and Cognitive Biases in Military Intelligence, by MAJ Elizabeth M. Marlin, US Army, 38 pages.

Information overload and cognitive biases are two challenges analysts face in the quest to produce timely intelligence. In today's digital world, analysts have access to more information than their human brains can process. Analysts draw on their personal experiences, training, and intuition to interpret the meaning of information. Analysts' judgments are susceptible to cognitive bias that can skew the intelligence process. Leveraging artificial intelligence to process data and analyze information provides analysts more time to synthesize knowledge and build situational understanding of the operational environment. A scenario development methodology explores two common tasks intelligence analysts perform and explores opportunities for integrating artificial intelligence.

Machines can process data and analyze information quickly and indiscriminately. Analysts apply meaning to the patterns extrapolated by artificial intelligence and evaluate implications for the operations. The analysts' experiences, training and expertise, and knowledge of the mission help the analysts make determinations on how and why the information matters. Analysts incorporate knowledge into the planning process to fuel the commander's situational understanding. Synthesized knowledge enables the commander to synchronize actions in time, space, and purpose.

Contents

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Acronyms

ADP	Army Doctrine Publication
ACH	Analysis of Competing Hypothesis
ADRP	Army Doctrine Reference Publication
ATP	Army Techniques Publication
ASCOPE	Areas, Structures, Capabilities, Organizations, People, and Events
BEI	Biometrics-Enabled Intelligence
CI	Counterintelligence
CIA	Central Intelligence Agency
CMU	Central Michigan University
CPOF	Command Post of the Future
DOMEX	Document and Media Exploitation
DSGC-A	Distributed Common Ground System-Army
FEI	Forensic-Enabled Intelligence
FM	Field Manual
GEOINT	Geospatial Intelligence
HUMINT	Human Intelligence
IBM	International Business Machines
IC	Intelligence Community
IPB	Intelligence Preparation of the Battlefield
ISR	Intelligence, Reconnaissance, and Surveillance
MCOO	Modified Combined Obstacles Overlays
MDMP	Military Decision Making Process
MIT	Massachusetts Institute of Technology
MSK	Memorial Sloan Kettering
OAKOC	Observation and Fields of Fire, Avenues of Approach, Key Terrain, Obstacles, Cover and Concealment

OMT	Operational Management Team
OSINT	Open Source Intelligence
SIGINT	Signals Intelligence
SWO	Staff Weather Officer
TECHINT	Technical Intelligence

Illustrations

Introduction and Literature Review

Information overload and cognitive biases are two challenges analysts face in the quest to produce timely intelligence. In today's digital world, analysts have access to more information than their human brains can process.[1] Analysts draw on their personal experiences, training, and intuition to interpret the meaning of information. Analysts' judgments are susceptible to cognitive bias that can skew the intelligence process. The United States Intelligence Community (IC) acknowledges these challenges and understands that managing the growing amount of available information is very relevant to how our country is fighting and planning for future threats.[2] The IC is looking for ways to overcome these challenges, to include exploring technology-based capabilities such as artificial intelligence. The Office of the Director of National Intelligence recently launched a $500,000 competition "to explore AI-based opportunities for generating analytic products that surpass those crafted by traditional, highly-trained IC analysts."[3] On July 13, 2017, *Breaking Defense* published an article stating that within six months the US military will use commercial artificial intelligence to sort through intelligence data on the Islamic State.[4] This development illustrates the potential for artificial intelligence to help harvest, analyze, and rapidly convert large data sets into actionable intelligence. The IC should view artificial intelligence as a beneficial option to help meet its evolving needs. Leveraging artificial intelligence to process data and analyze information provides analysts more time to synthesize knowledge and build situational understanding of the operational environment.

[1] Chris Young, "Military Intelligence Redefined: Big Data in the Battlefield," *Forbes*, March 12, 2012, accessed January 15, 2018, https://www.forbes.com/sites/techonomy/2012/03/12/military-intelligence-redefined-big-data-in-the-battlefield/#716158ae4080.

[2] Ibid.

[3] Office of the Director of National Intelligence, "DS&T AND OUSD(I) Launch "Xpress" Automated Analysis Challenge," May 16 2017, accessed July 17, 2017, https://www.dni.gov/index.php/ newsroom/ press-releases /item/1759-ds-t-and-ousd-i-launch-xpress-automated-analysis-challenge.

[4] Sydney J. Freedberg Jr., Breaking Defense, "Artificial Intelligence Will Help Hunt Daesh By December," July 13, 2017, accessed July 17, 2017, http://breakingdefense.com/2017/07/artificial-intelligence-will-help-hunt-daesh-by-december/.

Intelligence in War

As military intelligence continues to advance, it enhances the commander's ability to visualize and understand the operational environment.[5] Army Doctrine Publication (ADP) 3-0, *Operations* defines operational art as "the pursuit of strategic objectives, in whole or in part, through the arrangement of tactical actions in time, space, and purpose."[6] Operational art is critical to organizing the defeat of opposing forces, which requires knowing what functions are vital to an enemy's mission.[7] Sun Tzu asserted, "Know the enemy and know yourself; in a hundred battles you will never be in peril."[8] Sun Tzu stated, the consequences of knowing just oneself or just the enemy is a 50/50 chance or winning versus losing in battle, and if you are ignorant of both oneself and the enemy, you are certain to face grave danger. "Those skilled in war bring the enemy to the field of battle and are not brought there by him."[9] Sun Tzu's emphasis on knowing one's enemy and oneself reflects enemy's role in determining the outcome of battle. Sun Tzu is one of the first to theorize about intelligence in war. Although written in 500 B.C., the concept is timeless. The commander must arrange tactical actions to engage the enemy.

In order to arrange tactical actions effectively, the commander must have access to timely and accurate intelligence. Clausewitz described intelligence as "every sort of information about the enemy and his country—the basis, in short, of our own plans and operations."[10] Intelligence

[5] The commander's visualization and understanding of the operational environment facilitates the determination of how, when, where, and for what purpose military forces will be employed to achieve the strategic aim.

[6] US Department of the Army, Army Doctrine Publication (ADP) 3-0, *Operations* (Washington, DC: Government Printing Office, 2016), 4.

[7] US Department of the Army, Field Manual (FM) 3-0, *Operations* (Washington, DC: Government Printing Office, 2017), 1-20.

[8] Samuel B. Griffin, *Sun Tzu The Art of War* (New York: Oxford University Press, 2012), 96.

[9] Ibid.

[10] Carl Von Clausewitz, *On War*, ed. Peter Paret and Michael Howard (Princeton: Princeton University Press, 1984), 101.

provides the enemy situation as the starting point for the commander to visualize and understand the environment, and fuels planning of tactical actions in time, space, and purpose. Clausewitz explains, “War is the realm of uncertainty; three quarters of the factors on which action in war is based are wrapped in a fog of greater or lesser uncertainty. A sensitive and discriminating judgment is called for; a skilled intelligence to scent out the truth.”[11] Information overload and cognitive biases hinders the human mind from providing the discriminating judgment that Clausewitz asserts is required to “scent out the truth” within the uncertainty. Clausewitz stated that the nature of war will not change, but the character might. Machines are great at exploring options that human minds might not see. There is no socialization process for machines. This allows them to develop new and unusual assessments, including ideas not conceivable by humans. Additionally, machines follow programmed rules with precision, and can be equipped with unlimited memory capacity. Using artificial intelligence to assist in military intelligence analysis will be a character change for the better.

This monograph explores artificial intelligence as an option to assist where a human’s processing capacity falls short. The following literature review focuses on the topics of information overload, cognitive biases, and artificial intelligence to assist with understanding current analytical challenges and artificial intelligence practices. This information provides the basis for how to incorporate artificial intelligence into military intelligence analysis.

Information Overload

Army Doctrine Reference Publication (ADRP) 2-0 defines *intelligence analysis* as “the process by which collected information is evaluated and integrated with existing information to facilitate intelligence production.”[12] The most reliable form of intelligence analysis is *all-source intelligence*, which is the “integration of intelligence and information from all relevant sources in

[11] Clausewitz, *On War*, 101.

[12] US Department of the Army, Army Doctrine Publication (ADP) 2-0, *Intelligence* (Washington, DC: Government Printing Office, 2012), Glossary-2.

order to analyze situations or conditions that affect operations."[13] All-source intelligence derives from many single-source intelligence disciplines including counterintelligence (CI), geospatial intelligence (GEOINT), human intelligence (HUMINT), measurement and signature intelligence (MASINT), open-source intelligence (OSINT), signals intelligence (SIGINT), and technical intelligence (TECHINT). Complementary intelligence capabilities, including biometrics-enabled intelligence (BEI), cyber-enabled intelligence, document, and media exploitation (DOMEX), and forensic-enabled intelligence (FEI) contribute valuable information to all-source intelligence.[14] In the current digital age, intelligence analysts process massive amounts of information about individuals, sub-state actors, and governments every day.[15]

In his 1970 book *Future Shock,* Alvin Toffler of the International Institute for Strategic Studies popularized the term "information overload" to describe the difficulty in effectively making decisions when one has too much information to consider in a clear way.[16] Intelligence overload occurs when inputs into a system exceed the processing capacity of that system – in this case, the human mind. Alex Young, author for the Harvard International Review, draws the conclusion that the excessive amount of information inundating the intelligence community is causing information overload.[17] Information overload poses a serious challenge to effective intelligence analysis. When analysts lose the ability to pick out what is important from what is not, they fail to make good judgments.

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[13] US Army, ADP 2-0 (2012), 10.

[14] US Army, ADP 2-0 (2012), 11.

[15] Alex Young, "Too Much Information Ineffective Intelligence Collection," *Harvard International Review*, August 20, 2013, accessed September 7, 2017, http://hir.harvard.edu/article/?a=10382.

[16] *Cambridge Dictionary*, "Information Overload," accessed September 7, 2017, http://dictionary.cambridge.org/us/dictionary/english/information-overload.

[17] Young, "Too Much Information Ineffective Intelligence Collection."

Carmen Medina, former Central Intelligence Agency (CIA) deputy director for intelligence, asserts that analysis must radically change to survive the information revolution.[18] Medina claims the IC is in a new era of analysis, one caused by the proliferation of digital media.[19] Former chairman for the National Intelligence Council John C Gannon adds:

> The IC, in one generation, passed from an information-scarce environment to an information-glut environment. Major advances in technical collection provided more data than analysts could exploit. Technology promised to save labor for the IC managers and analysts, but the opposite occurred. It has made analysts more efficient, customers more demanding, and the workload heavier. To be fair, the intelligence bureaucracy has made more serious efforts, many of them successful, to respond to the technological challenge. Analysts today are filtering, searching, and prioritizing massive volumes of information employing link analysis, time-series analysis, visualization, and automated database population. To be accurate, however, the overall effort-especially with regard to the exploitation of open source information-has fallen short of the mark.[20]

Gannon asserts, IC leaders must exploit an unprecedented abundance of open source information, some of which is of high intelligence value. In order to maintain its competitive edge, Gannon calls for the IC to strengthen its management and "boost the community's analytical capabilities by aggressively exploiting technology…and by forging enduring partnerships with experts outside the community-especially in the scientific world."[21]

Cognitive Biases

Psychology, medical, business, and intelligence professionals contribute to the vast research that exists on the study of perceptual and cognitive biases. Many professionals in the intelligence field believe analysts can learn to recognize and overcome their biases through

[18] Carmen Medina, "Leading Analytic Change," in *Analyzing Intelligence Origins, Obstacles, and Innovation*, eds. Roger Z. George and James B. Bruce (Washington DC: Georgetown University Press, 2008), 212.

[19] Carmen Medina, "The New Analysis," in *Analyzing Intelligence Origins, Obstacles, and Innovation*, eds. Roger Z. George and James B. Bruce (Washington DC: Georgetown University Press, 2008), 238-248.

[20] John C. Gannon, "Managing Analysis in the Information Age," in *Analyzing Intelligence Origins, Obstacles, and Innovation*, ed. Roger Z. George and James B. Bruce (Washington DC: Georgetown University Press, 2008), 217-218.

[21] Ibid., 213-216.

intelligence training and by implementing structured methods. The analysis of competing hypotheses (ACH) is a common example of a structured method. ACH is a systematic approach that considers a range of alternative explanations and evaluation to disconfirm rather than confirm hypotheses.[22]

The Miniature Guide to Critical Thinking declares, “Everyone thinks; it is our nature to do so. But much of our thinking, left to itself, is biased, distorted, partial, uninformed or down-right prejudiced.”[23] CIA veteran Richards J. Heuer Jr. is a noted professional in the study of cognitive biases. Heuer examines obstacles to intelligence analysis and provides techniques for overcoming mind-sets and cognitive biases. Heuer asserts, “Major intelligence failures are usually caused by failures of analysis, not failures of collection. Relevant information is discounted, misinterpreted, ignored, rejected, or overlooked because it fails to fit a prevailing…mind-set.”[24] Heuer writes of the value and the dangers of mental models, or mind-sets.

> Mental models are critical to allowing individuals to process what otherwise would be an incomprehensible volume of information. Yet, they can cause analysts to overlook, reject, or forget important incoming or missing information that is not in accord with their assumptions and expectations. Seasoned analysts may be more susceptible to these mind-set problems as a result of their expertise and past success in using time-tested mental models. The key risks of mind-sets are that: analysts perceive what they expect to perceive; once formed, they are resistant to change; new information is assimilated, sometimes erroneously, into existing mental models; and conflicting information is often dismissed or ignored.[25]

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[22] Central Intelligence Agency, “A Tradecraft Primer: Structured Analytic Techniques for Improving Intelligence Analysis,” US Government, March 2009, accessed September 7, 2017, http://www.analysis.org/ structured-analytic-techniques.pdf, 11.

[23] Richard Paul and Linda Elder, *The Miniature Guide to Critical Thinking*, 4th ed. (Dillon Beach, CA: Foundation for Critical Thinking, 2006), 2.

[24] Richards J. Heuer Jr., *Psychology of Intelligence Analysis* (Washington, DC: Central Intelligence Agency, 1999), 65.

[25] Ibid., 111.

Heuer explains cognitive biases are mental short cuts that are neither good nor bad, but are consistent and predictable mental errors.[26] The intelligence publication, A Tradecraft Primer: Structured Analytic Techniques for Improving Intelligence Analysis, outlines common perceptual and cognitive biases in four categories: perceptual biases, biases in evaluating evidence, biases in estimating probabilities, and biases in perceiving causality. The primer highlights these biases to help analysts challenge their judgments, identify mental mindsets, simulate creativity, and manage uncertainty.[27]

Common Perceptual and Cognitive Biases

Perceptual Biases	Biases in Evaluating Evidence
Expectations. We tend to perceive what we expect to perceive. More (unambiguous) information is needed to recognize an unexpected phenomenon. **Resistance**. Perceptions resist change even in the face of new evidence. **Ambiguities.** Initial exposure to ambiguous or blurred stimuli interferes with accurate perception, even after more and better information becomes available.	**Consistency.** Conclusions drawn from a small body of consistent data engender more confidence than ones drawn from a larger body of less consistent data. **Missing Information.** It is difficult to judge well the potential impact of missing evidence, even if the information gap is known. **Discredited Evidence.** Even though evidence supporting a perception may be proved wrong, the perception may not quickly change.
Biases in Estimating Probabilities	**Biases in Perceiving Causality**
Availability. Probability estimates are influenced by how easily one can imagine an event or recall similar instances. **Anchoring.** Probability estimates are adjusted only incrementally in response to new information or further analysis. **Overconfidence.** In translating feelings of certainty into a probability estimate, people are often overconfident, especially if they have considerable expertise.	**Rationality.** Events are seen as part of an orderly, causal pattern. Randomness, accident and error tend to be rejected as explanations for observed events. For example, the extent to which other people or countries pursue a coherent, rational, goal-maximizing policy is overestimated. **Attribution.** Behavior of others is attributed to some fixed nature of the person or country, while our own behavior is attributed to the situation in which we find ourselves.

Figure 1. Common Perceptual and Cognitive Biases, "A Tradecraft Primer: Structured Analytic Techniques for Improving Intelligence Analysis," March 2009, accessed September 7, 2017, http://www.analysis.org/ structured-analytic-techniques.pdf, 2.

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[26] Heuer, *Psychology of Intelligence Analysis*. 111.

[27] Central Intelligence Agency, "A Tradecraft Primer," 2-11.

CIA veteran James Bruce claims that individuals possess knowledge through five principles of knowing: authority, habit of thought, rationalism, empiricism, and science.[28] He states that understanding how and why you know something is important and can assist in overcoming personal biases. Critical thinking is the art of analyzing thoughts and is necessary to overcome personal biases. Critical thinking's self-corrective focus aims to overcome innate human egocentrism and sociocentrism. US Army War College professor Stephen Gerras defines an egocentric memory as, "the natural tendency to forget information that does not support their line of thinking."[29]

Many authors advocate for structured tools like the scientific method and critical thinking to mitigate biases. Stephen Marrin, Director of the James Madison University Intelligence Analysis Program, claims that structured analytical methods provide a way to account for judgment and can make the analytic process transparent.[30] The scientific method and ACH provide ways for analysts to identify their personal biases. This understanding allows them to see how their biases play a role in their thinking and intelligence analysis.

The US government issued "A Tradecraft Primer" in 2009 with techniques to instill more structure into intelligence analysis, and to make analytic arguments more transparent by articulating and challenging key assumptions, examining alternative outcomes, and identifying indicators of change that can reduce the chance of surprise. The analyst evaluates the completeness and soundness of available information sources using a technique called *quality of information check*. Analysts use this technique to understand how they gained specific

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[28] James Bruce, "Making Analysis More Reliable: Why Epistemology Matters to Intelligence," in *Analyzing Intelligence Origins, Obstacles, and Innovation*, eds. Roger Z. George and James B. Bruce (Washington, DC: Georgetown University Press, 2008), 172.

[29] Stephen J. Gerras, "Thinking Critically About Critical Thinking: A Fundamental Guide for Strategic Leaders," *Planners Handbook for Operational Designs*, Version 1.0, (Suffolk, VA: Joint Staff, 2011), C9-10.

[30] Stephen Marrin, "Intelligence Analysis: Structured Methods or Intuition?" *American Intelligence Journal* (Summer 2007): 7.

knowledge. Heuer's concept of ACH is the most often cited intelligence analysis methodology or structured technique. This technique helps analysts avoid prematurely accepting the first solution that appears satisfactory. ACH requires consideration of all reasonable solutions and protects against the analysts' tendencies to ignore or discount information that does not fit their preferred or expected hypothesis.[31] ACH provides transparency as it identifies considered theories and provides a matrix that outlines how analysts arrived at their judgments.

Another noted writer in the realm of cognitive biases is Daniel Kahneman, who received the Nobel Prize in Economic Science in 2002 for his integration of psychological research into economics. In his book *Thinking, Fast and Slow*, Kahneman documented systematic errors in the thinking of normal people, which he traced back to the design of the machinery of cognition.[32] Kahneman writes of the different ways the brain forms thoughts, which he labels System 1 and System 2. System 1 is the fast, automatic, frequent, emotional, and subconscious thinking that encompasses thinking associated with tasks of walking, breathing, casual driving. Simple mental rules of thumb and cognitive biases result in impressions, feeling, and inclinations that drive this System 1 thinking. System 2 is the slow, effortful, logical, calculating, and conscious thinking that governs tasks like sustaining a fast-paced walk, determining the appropriate response to behavior in a social setting, and parallel parking in a tight space. System 2 thinking is slow, rational, and based on considered evaluation that results in a deliberate conclusion.

System 1 and System 2 work together. System 1 is the autopilot and because System 2 is lazy, it typically adopts the recommendations of System 1.[33] This creates issues when System 1 jumps to conclusions based on cognitive biases. For example, Kahneman explains that System 1 often falls victim to "what you see is all there is," meaning that System 1 only considers available

[31] Central Intelligence Agency, "A Tradecraft Primer," 14.

[32] Daniel Kahneman, *Thinking, Fast and Slow* (New York: Farrar, Straus and Giroux, 2011), 119-129.

[33] Ibid.

information and tries to form a coherent story. Substitution is a mental error where the brain replaces difficult questions for easier ones. Kahneman's study includes many of the cognitive biases that affect intelligence analysis including the anchoring effect and availability bias.

Kahneman claims being aware of the pitfalls of System 1 thinking helps activate System 2 thinking. He recommends meditation, mindfulness, and meta-thinking to stimulate critical thought. Additional techniques include avoiding email in the early morning and late night, taking a daylong hiatus from electronic communications, and journaling. These techniques prepare the mind for meaningful System 2 activity.

Professionals in most major fields study cognitive bias and their effects on thinking, analysis, and decision-making. The IC understands analysts rely on mental shortcuts due to data overload. Therefore, the IC advocates including more structured methods into intelligence analysis to account for, and overcome, mental errors associated with shortcuts. The most common structured method used is ACH, which compares numerous hypotheses and provides transparent documentation that is shareable with other analysts. However, the approaches recommended to overcome cognitive biases are time consuming. In today's operational environment, there is never enough time to analyze all the available information. This is where artificial intelligence is able to assist intelligence analysts.

Artificial Intelligence

Artificial intelligence is the concept of digital computers or computer-controlled robots performing functions normally associated with human beings. American computer and cognitive scientist John McCarthy coined the term "artificial intelligence" in 1955.[34] McCarthy organized the first academic conference dedicated to the pursuit of artificial intelligence on the Dartmouth

[34] World-Information.Org, "1950s: The Beginning of Artificial Intelligence (AI) Research," accessed October 31, 2017, http://world-information.org/wio/infostructure/100437611663/100438659360.

campus in 1956.[35] This conference drew talent and expertise to a two-month brainstorming session focused on machine intelligence. Computer scientists from Massachusetts Institute of Technology (MIT), Central Michigan University (CMU), Stanford and International Business Machines (IBM) met at the conference to discuss duplicating human traits like creativity, self-improvement, and language. The artificial intelligence field is the only field to attempt to build machines that function autonomously in complex, changing environments.[36]

In his 1987 monograph, "Artificial Intelligence and National Defense: Application to C3I and Beyond," Joel Daniels asserts that artificial intelligence is "the application of knowledge, thought, and learning to computer systems to aid humans…involved in either the extraction or the generation of information and in understanding the surrounding environment."[37] Currently, Stuart Russell and Peter Norvig's textbook *Artificial Intelligence: A Modern Approach* serves as an academic foundation for the education of artificial intelligence in many universities.[38] Russell and Norvig briefly cover the history and theory of general artificial intelligence before delving into modern approaches for current applications of artificial intelligence.[39]

Artificial intelligence is rooted in the scientific method. This ensures transparency, as hypotheses undergo rigorous empirical experiments, which must produce replicable results.[40] Artificial intelligence operates in a wide range of activities including driverless vehicles, automated speech recognition, dialog management system (used by many businesses for things

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[35] Nicholas Carr, *The Shallows: What the Internet Is Doing to Our Brains* (New York: W.W. Norton & Company, 2010), 174-75.

[36] Peter Norvig and Stuart Russell, *Artificial Intelligence: A Modern Approach*, 3rd ed. (Edinburch Gate: Pearson Education, 2016), 17-18.

[37] Joel Daniels, *Artificial Intelligence and National Defense: Application to C3I and Beyond*, (Washington, DC: AFCEA International Press, 1987), 3-11.

[38] AIMA Homepage, "Artificial Intelligence: A Modern Approach,"modified January 8, 2018, accessed February 18, 2018. http://aima.cs.berkeley.edu/.

[39] Peter Norvig and Stuart Russell, *Artificial Intelligence: A Modern Approach*, 17-18.

[40] Ibid., 25.

like making a payment by phone), autonomous planning and scheduling, spam fighting, logistics planning, machine translation, robotics (like Roomba robotic vacuum cleaners) and game playing.[41]

Artificial intelligence covers a wide variety of applications. Narrow artificial intelligence attempts to complete specific tasks better than humans. An example of narrow artificial intelligence is IBM's DeepBlue, the program designed to beat humans in chess. Chess is complicated, yet the environment is well defined. Artificial intelligence can calculate all the pertinent information and make chess moves with few errors. IBM's DeepBlue beat Russian chess champion Garry Kasparov in 1997. Another example is IBM's "Watson," a computer system developed to answer questions on the show Jeopardy! Watson had access to over four terabytes of data from encyclopedias, dictionaries, thesauri, newswire articles, literary works, and previous shows. Figure 2 illustrates how Watson analyzed and evaluated the data to outperform humans on the show in 2011.

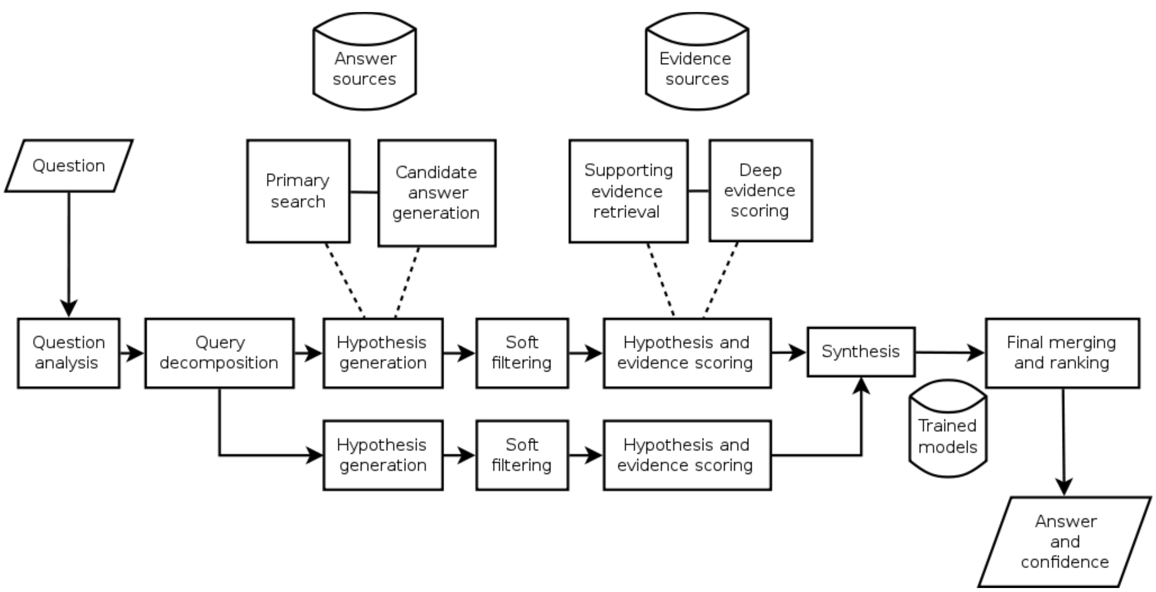

Figure 2. David Ferrucci, Eric Brown, Jennifer Chu-Carroll, James Fan, David Gondek, Aditya A. Kalyanpur, Adam Lally, J. William Murdock, Eric Nyberg, John Prager, Nico Schlaefer, and Chris Welty, "Building Watson: An Overview of the DeepQA Project," *Artificial Intelligence Magazine* (Fall 2010): 69.

[41] Peter Norvig and Stuart Russell, *Artificial Intelligence: A Modern Approach*, 29.

Figure 3 outlines the different subcategories within the artificial intelligence field. Some algorithms combine multiple subcategories. For example, vision includes both image recognition and machine vision, technologies that incorporate machine and deep learning algorithms.

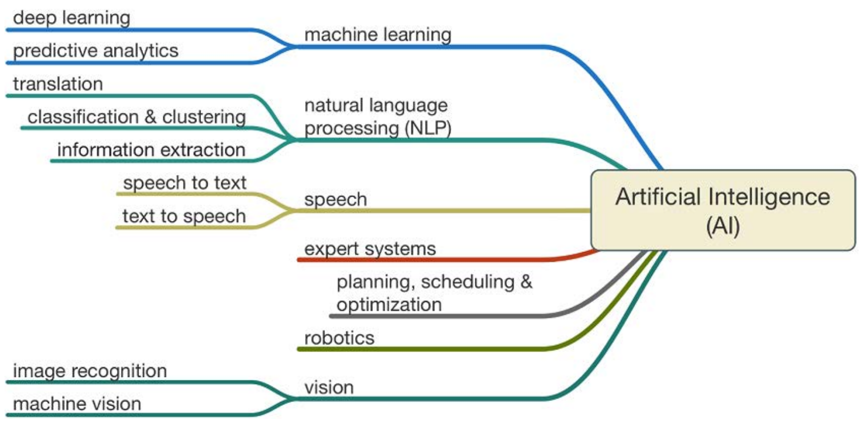

Figure 3. Rron Beqiri, "A.I. Architecture Intelligence," Future Architecture Platform, May 4, 2016, accessed October 30, 2017, http://futurearchitectureplatform.org/news/28/ai-architecture-intelligence/.

Machine learning is a type of artificial intelligence that provides computers the ability to learn without human oversight.[42] Machine learning is the ability to adapt to new circumstances and to detect and extrapolate patterns.[43] Deep learning, coined by Geoff Hinton in 2006, is a fast-growing area in machine learning. The difference between deep learning and traditional machine learning is the removal of feature extraction, where the programmer must tell the computer what kinds of things will be informative in making a decision. In deep learning, the computer learns to identify what helps make a decision.[44] For example, less than a decade ago, only search engines and assembly line inspections used image recognition. If a person conducted a Google search for images of a "dog," every image previously input with a tag including the term "dog" would

[42] Machine Learning, "Machine Learning Algorithms: Predictive Modeling, Data Analytics, and Artificial Intelligence, accessed October 30, 2017, http://www.machinelearningalgorithms.com/.

[43] Russell and Norvig, *Artificial Intelligence: A Modern Approach*, 2.

[44] Nikihil Buduma, "Deep Learning in a Nutshell-What it is, how it works, why care?" KDnuggets, accessed October 31, 2017, https://www.kdnuggets.com/2015/01/deep-learning-explanation-what-how-why.html.

appear. The search results depended on proper tagging. Deep learning technology makes it possible for the computer to find, analyze, and categorize images without tags. Deep learning organizes neural nets into stacked layers that enables a machine to find patterns in unstructured data. Figure 4 illustrates how deep learning allows the computer to identify an image as a "dog." Neural networks learn by adjusting the strength of the connections through multiple layers. This process allows the computer to filter out inappropriate images, known as noise, and retain only the most relevant ones. The computer "learns" and becomes more accurate as it processes more data.

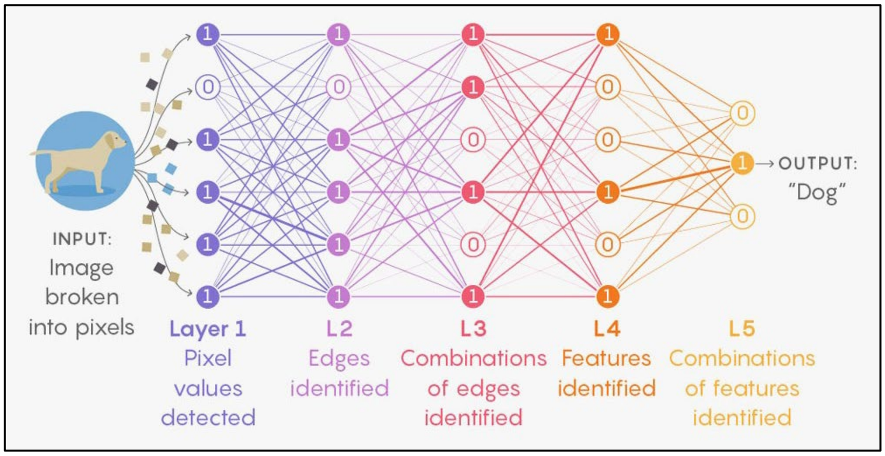

Figure 4. Eric Nyquist, "New Theory Cracks Open the Black Box of Deep Learning," *Qunata Magazine*, accessed October 30, 2017, https://www.quantamagazine.org/new-theory-cracks-open-the-black-box-of-deep-learning-20170921/.

Artificial intelligence gained international attention when Google's artificial intelligence powered AlphaGo beat the world Go champion Lee Sedol in March 2016. Machines already had victories over human champions in checkers, chess, Othello, and *Jeopardy!*, but winning in Go was a defining moment. Go is exponentially more complex than other games and requires an added degree of intuition.[45] AlphaGo observed human behavior, developed an understanding of the game, and devised competitive strategies. AlphaGo's strategies were unorthodox to humans

[45] Cade Metz, "Google's AI Wins Fifth and Final Game Against Go Genius Lee Sedol." *WIRED*, last modified 2016, accessed March 11, 2017, https://www.wired.com/2016/03/googles-ai-wins-fifth-final-game-go-genius-lee-sedol.

experienced in the game. After training with human assistance, AlphaGo used deep learning to play against itself millions of times. The computer did not learn by continuously playing humans; therefore, it made moves uncommon to human players. This illustrates the possibility that artificial intelligence can overcome human biases in intelligence analysis. This also gave the computer a strategic advantage against his competitor who used additional time to contemplate his next move. In game five, AlphaGo made an amateur mistake that no moderately skilled human player would make. However, AlphaGo was still able to recover and win the game. AlphaGo's technology far surpassed expectations, specifically the prediction it would beat living humans by 2025.[46]

Facebook, a popular social media platform, uses deep learning in a variety of ways. Facebook uses a tool called DeepText for textual analysis. It extracts meaning from words posted by users and markets products to users based on their posted conversations and status updates. The DeepText algorithm learns for itself and overcomes variations in spelling, slang or idiosyncrasies of language by analyzing common word usage. Facebook also uses a recognition tool called DeepFace to identify and automatically tag your friends in photos.[47] Figure 5 below illustrates the alignment pipeline DeepFace uses to help overcome the challenges of unconstrained face verification (invariant to pose, illumination, expression, and image quality). DeepFace uses an analytical 3D model of the face based on fiducial points as described below.

(a) The detected face, with 6 initial fiducial points. (b) The induced 2D-aligned crop. (c) 67 fiducial points on the 2D-aligned crop with their corresponding Delaunay triangulation, we added triangles on the contour to avoid discontinuities. (d) The reference 3D shape transformed to the 2D-aligned crop image-plane. (e) Triangle visibility w.r.t. to the fitted 3D-2D camera; darker triangles are less visible. (f) The 67 fiducial points induced by the 3D model that are used to

[46] Metz, "Google's AI Wins Fifth and Final Game Against Go Genius Lee Sedol."

[47] Bernard Marr, "4 Mind-Blowing Ways Facebook Uses Artificial Intelligence," *Forbes*, December 29, 2016, accessed October 31, 2017, https://www.forbes.com/sites/bernardmarr/2016/12/29/4-amazing-ways-facebook-uses-deep-learning-to-learn-everything-about-you/2/#20c6e56b3090, 2.

direct the piece-wise affine warping. (g) The final formalized crop. (h) A new view generated by the 3D model.[48]

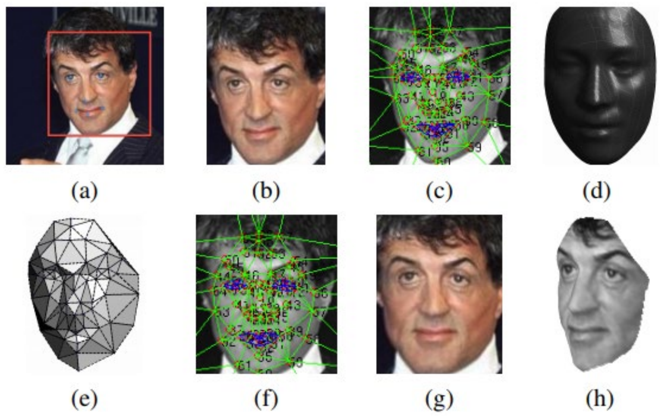

Figure 5. Yaniv Taigman, Ming Yang, and Marc'Aurelio Ranzato, "DeepFace: Closing the Gap to Human-Level Performance in Face Verification," Facebook AI Research, accessed November 1, 2017, https://research.fb.com/wp-content/uploads/2016/11/deepface-closing-the-gap-to-human-level-performance-in-face-verification.pdf?https://www.quantamagazine.org/new-theory-cracks-open-the-black-box-of-deep-learning-20170921/, 2.

Artificial intelligence, specifically machine learning, is also being used in the medical field. Similar to intelligence analysis, medicine is both an art and science. Doctors rely on their rigorous medical training but diagnosis decisions equally include knowledge from previous experience with patients, discussion with colleagues, and their general understanding of the human body.[49] The medical field is using machine learning to assist doctors in making quicker and more accurate diagnoses. IBM's Watson Health uses artificial intelligence technology with powerful cognitive computing to analyze relevant information, like symptoms, family history of diseases, and stage of their cancer to offer potential treatments. Watson for Oncology collaborated with New York's Memorial Sloan Kettering Cancer Center (MSK) to develop an

[48] Yaniv Taigman, Ming Yang, and Marc'Aurelio Ranzato, "DeepFace: Closing the Gap to Human-Level Performance in Face Verification," Facebook AI Research, accessed November 1, 2017, https://research.fb.com/wp-content/uploads/2016/11/deepface-closing-the-gap-to-human-level-performance-in-face-verification.pdf?https://www.quantamagazine.org/new-theory-cracks-open-the-black-box-of-deep-learning-20170921/, 2.

[49] Alice Park, "How Robots Are Changing the Way You See a Doctor," *Time.com*, October 6, 2017, accessed November 1, 2017, http://time.com/4967153/artificial-intelligence-machine-learning/.

application that provides access to the expertise of MSK oncologists.[50] Doctors around the world can tap into the vast knowledge within Watson to identify evidence-based, patient-centric treatment options. Watson for Oncology provides potential treatments with confidence and risk percentages for each option. It assists doctors who may not have personal experience with new drugs or particularly rare forms of cancer. The recommendations for treatments include standard approved therapies, treatments approved for other cancers and in the testing process for the patient's cancer, and truly experimental treatments that studies indicate might be effective. This provides doctors with more options to try if the standard treatments are ineffective. Watson's technology reduces risk of exposure to harmful side effects by choosing the most appropriate treatments based on the patient's information. Watson can incorporate new treatments and practices faster than doctors can. Doctors with less experience can have more confidence in their prescribed treatments because they have institutional knowledge from leading experts throughout the field.[51]

It is unquestionable that artificial intelligence is achieving remarkable accomplishments in the civilian sector. Machine learning and deep learning allow machines to process huge amounts of data and accurately make complex calculations quickly. The computer's ability to interpret and process huge amounts of information surpasses human's ability. Due to the breakthroughs in artificial intelligence and the existence of information overload and biases in the intelligence process, this paper explores how incorporating artificial intelligence can minimize information overload and cognitive biases in military intelligence analysis.

The literature review helped explain the theoretical framework behind the use of intelligence in war through the lens of Sun Tzu's and Clausewitz's writings, and analyzed two

[50] Laura Lorenzetti, "Here's How IBM Watson Health is Transforming the Health Care Industry," *Fortune.com*, April 5, 2016, accessed November 1, 2017, http://fortune.com/ibm-watson-health-business-strategy/.

[51] Alice Park, "How Robots Are Changing the Way You See a Doctor."

key challenges within the military intelligence community: information overload and cognitive biases. Unfortunately, minimizing the negative impacts of both challenges require more deliberate analysis using structured and transparent methods. These methods require additional time that is not always available in today's operating environment. Therefore, the IC is exploring potential artificial intelligence solutions to these two challenges. An examination of artificial intelligence concepts provide an understanding of what artificial intelligence is, how it works, and current commercial practices.

Methodology

This research uses a scenario development methodology to analyze where artificial intelligence can assist military intelligence analysts. Two scenarios review where a traditional human analyst would be required to analyze large amounts of data. Each scenario examines the potential to incorporate artificial intelligence to assist the analyst with the data processing and information analysis needed to develop intelligence.

Both scenarios focus on tactical planning using the Military Decision Making Process (MDMP), Step 2- Mission Analysis, specifically the initial Intelligence Preparation of the Battlefield (IPB). Clausewitz acknowledged that uncertainty always exists in war but that intelligence should serve as the starting point. The Commander relies on the intelligence staff to provide information and analysis on the terrain, enemy, and friendly forces that most affect tactical operations.

The first scenario focuses on building association matrices and link diagrams from intelligence reports. IPB aims to understand key personalities and relationships within the operational environment. Analysts should identify key personnel and locations within the operational environment that affect operations. Analysts use association matrices and link diagrams to understand where to gather additional information through source directed requirements and further Intelligence, Reconnaissance, and Surveillance (ISR) collection.

The second scenario analyzes the ability of artificial intelligence to conduct terrain and weather analysis. During planning, analysts provide assessments of how the terrain and weather will affect both friendly and enemy operations.

The final section of this monograph highlights opportunities to incorporate artificial intelligence into military intelligence analysis. It proposes the optimal points where artificial intelligence can automate or augment intelligence analysis to minimize information overload and cognitive biases. Lastly, it provides some potential risks associated with artificial intelligence. This monograph uses conceptual ideas how artificial intelligence can assist military intelligence analysts, and through practice examples, provides operational recommendations for artificial intelligence integration.

Scenario Development and Analysis

The commander and staff conduct mission analysis to gain a better understanding of the situation and "identify what the command must accomplish, when and where it must be done, and most importantly why- the purpose of the operation."[52] The intelligence staff conducts IPB, the systematic, continuous process of analyzing the threat and environment in a specific geographic area. The intelligence products and analysis from IPB aid in the development friendly courses of action and associated decision points for the commander. The analysis from IPB is also important for planning intelligence collection and targeting operations. IPB refinement is critical throughout operational planning and execution.[53] IPB consists of four steps: define the operational environment, describe environmental effects on operations, evaluate the threat, and determine threat courses of action. When defining the operational environment the intelligence staff identifies significant characteristics of the enemy, terrain, weather, and civil considerations that

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[52] US Department of the Army, Field Manual (FM) 6-0, *Command and Staff Organization and Operations* (Washington, DC: Government Printing Office, 2016), 9-6.

[53] US Department of the Army, Army Techniques Publication (ATP) 2-01.3, *Intelligence Preparation of the Battlefield/Battlespace* (Washington, DC: Government Printing Office, 2014), 1-1.

are relevant to the mission. Understanding cultural factors such as languages and tribal affiliation are key aspects to understanding the enemy. Civilian institutions, attitudes, and activities of the civilian leaders, populations, and organization within the area have significant impacts on operations. To evaluate the civil considerations, analysts use the memory aid ASCOPE (areas, structures, capabilities, organizations, people, and events). Analysts sometimes use association matrixes and link diagrams when examining the elements of ASCOPE. Association matrixes illustrate the known and suspected relationships among people, objects, locations, and organizations. Similarly, link diagrams are powerful analytical tools that visually depict the linkages between and among individuals, cells, and groups. Link diagrams are ideal for revealing hidden connections and the structure of clandestine, organized criminal entities including intelligence operations, terrorist groups, organized crime syndicates, and narcotics cartels.[54]

Link diagraming is effective for complex analysis; however, the technique is time consuming and tedious. Therefore, link diagraming is often underused.[55] Analyst use five steps to build a link diagram: 1) data mine, 2) analyze intelligence reports, 3) create the nodes, 4) organize the nodes, and 5) refine as more intelligence becomes available. Analysts conduct a search of various organizations' data files within the intelligence enterprise and review available intelligence reports from multiple sources, including HUMINT, SIGINT, and Open Source Intelligence (OSINT). Key word searches of names and locations can reveal hundreds, if not thousands, of reports depending on how long United States Forces and interagencies have been collecting on the area, individuals, and organizations. This creates information overload, as the analysts must review each report to gather information and determine if these persons and locations are the ones in their area of operations or area of influence. Although naming conventions exist, confusion can arise when different agencies use different spellings for foreign

[54] ORION Scientific Systems, "Link Analysis," AAAI Technical Report FS-98-01, accessed December 8, 2017, https://www.aaai.org/Papers/Symposia/Fall/1998/FS-98-01/FS98-01-013.pdf.

[55] Ibid.

names. Additionally, shortened names like Abu Bakr can refer to numerous people. One individual can also have multiple aliases, making effective analysis of reports extremely difficult. Analysts often have issues remembering foreign names. Cognitive biases habitually cause junior and inexperienced analysts to skim over the names when reading intelligence reports. These analysts internalize common Western or American names and have difficulties recalling foreign names or associating them with individuals. Creating and manipulating the nodes for each individual, location, organization, etc. is a time-consuming process that can take hundreds of man-hours. After creating the nodes, the analysts organize the link diagram to show threat group membership, cells, or participation in activities like logistics, finance, recruiting. Lastly, as new intelligence becomes available analysts adjust or refine the link diagram to incorporate prudent information. Subordinate units provide intelligence to answer HUMINT source-directed requirements. HUMINT reporting filters through the Operational Management Team (OMT) and the collection manager before the analysts have access. Adjacent or outside intelligence agencies also write intelligence reports, in which case analysts would not necessarily know that the reporting is available, unless the analyst conducts another data mine. These challenges add to the reluctance to use association matrices and link diagrams to help analyze complex networks.[56]

The time constraints associated with today's operating environment, exacerbate information overload and cognitive biases in intelligence analysis. IBM's Watson's performance on *Jeopardy!* illustrates artificial intelligence's ability to data mine large amounts of data very quickly. Military intelligence analysts could use similar technology to help data mine intelligence reports to develop association matrices and link diagrams. Narrow artificial intelligence and machine learning can process data for particular areas and keyword searches can quickly determine the important personalities within a given area of operations and area of influence. Parameters set to analyze a particular area of operations would allow artificial intelligence to data

[56] ORION Scientific Systems, "Link Analysis," 76.

mine all intelligence documents with reported locations within that area. Artificial intelligence can determine key personalities and locations based on the information within the documents and the amount of documents associated with individuals or locations. This will assist analysts in understanding critical personalities and their associations with various groups or activities.

Artificial intelligence can assist with analyzing intelligence reports as well. For instance, facial recognition technology similar to Facebook's Deep Face, could analyze pictures within intelligence databases to identify an individual with reports under multiple aliases. Natural language processing can conduct data extraction and classification of individuals and locations and assist with overcoming spelling differences within intelligence reports. This helps the analysts overcome cognitive biases associated with the difficulty remembering foreign names. Availability and anchoring biases affect intelligence analysis, as analysts faced with time constraints might not fully analyze all available intelligence reports. There is a tendency to anchor to the reports read first and resist change, even in the face of new evidence. Deep learning can minimize the availability bias through its capability to analyze vast amounts of data. Additionally, deep learning's ability to evaluate all information independently, limits anchoring bias. Deep learning can evaluate individuals that frequent the same locations to determine patterns of life and expected time for potential future visits.

The Army's intelligence system of record, Distributed Common Ground System-Army (DSGC-A), has a tool that populates nodes or entities into a link diagram. This link diagram tool creates nodes or entities from selected reports. Analysts have challenges using this tool because the technology is not intuitive and requires intensive initial training as well as continued refresher training. Analysts consistently state they cannot maintain a high level of DCSG-A proficiency without constantly using the system.[57] Although DCGS-A is difficult to use, it does exist and the

[57] J. Michael Gilmore, Distributed Common Ground System-Army (DCGS-A) Increment 1 Release 2 Follow-on Operational Test and Evaluation (FOT&E) Report, January 2016, accessed December 13, 2017, http://www.dtic.mil/dtic/tr/fulltext/u2/1007951.pdf.

link diagram can create nodes from reports. The nodes have the intelligence reports embedded to provide transparency on why the links exist and allow analysts to reference the reporting documentation when creating intelligence products.

The link diagram tool has technology that allows the analyst to organize the link diagram. For instance, the analyst can drag particular nodes or entities to different spaces and adjust the diagram. Boxes can be added and labeled for identify cells or to distinguish different activities. Machine and deep learning would be beneficial in that it could automatically label and organize the nodes or entities based on the intelligence reporting.

Refining the association matrixes and link diagrams, as more intelligence is available is critical to maintaining situational understanding of the area of operations and area of influence as it changes. Targeting efforts drive changes in how enemies operate. Currently, analysts must continue data mining to discover new intelligence reports; however, artificial intelligence can automatically data mine and research all names and locations annotated in the association matrix and link diagrams. Machine and deep learning can adjust the embedded documentation behind the nodes and entities and highlight differences for the analysts.

This scenario illustrates artificial intelligence can assist analysts throughout the five steps of creating link diagrams. Artificial intelligence in the form of facial recognition, natural language process, machine and deep learning can help analysts avoid information overload and cognitive biases by data mining, analyzing reports, creating nodes and entities, organizing link diagrams, and continuously refining the product.

The second scenario focuses on step two of IPB: describe environmental effects on operations. This step includes four sub-steps: describe how threat/adversary can affect friendly operations, describe how terrain can affect friendly and threat/adversary operations, describe how weather can affect friendly and threat/adversary operations, and describe how civil considerations can affect friendly and threat/adversary operations. This scenario explores integrating artificial intelligence within terrain and weather analysis and presents opportunities for machine and deep learning to assist analysts with understanding the operational environment as a system. Similar to the first scenario, this scenario examines how a human analyst conducts terrain and weather analysis, and then proposes ways to incorporate artificial intelligence to avoid information overload and cognitive biases.

Effective IPB analyzes the relevant mission variables of enemy, terrain, weather, and civil considerations and describes how each of these variables may affect friendly and adversary operations and decision-making. The modified combined obstacles overlay (MCOO) is a key output of terrain analysis. The MCOO and the terrain effects matrix assist the commander and staff with visual tools that portray the effects the natural and urban terrain will have on military operations. The MCOO includes significant aspects of the terrain that can affect movement including avenues of approach, mobility corridors, natural and manmade obstacles, key terrain, and terrain mobility classifications.[58] Analysts produce the MCOO as an analog map overlay, using digital mapping tools, or a combination of the two. Prior to vast computer usage, analysts typically evaluated the terrain using a map with an acetate overlay.

In 2006, Command Post of the Future (CPOF) became part of the Army's Program of Record.[59] CPOF is a dynamic visualization tool that allows commanders to see the battlefield and collaborate with other leaders in real time, regardless of their physical locations.[60] Commanders use CPOF for their daily update briefs because its technology provides a common operating picture, including unit graphics, control measures, and other information, for all leaders across the

[58] US Army, ATP 2-01.3 (2014), 2-1.

[59] M.S. Vassilliou, S.O. Davis, and Jonathan Agre, "Innovation Patterns in Some Successful C2 Technologies," Institute for Defense Analysis, January 2011, accessed February 15, 2018, file:///C:/Users/1271628656.MIL/Downloads/ADA541139.pdf, 8.

[60] Nancy Jones-Bonbreast, "U.S. Army's Common Operating Picture Tool Continues to Evole," *US Army*, December 5, 2012, accessed February 15, 2018, https://www.army.mil/article/92364.

battlefield.[61] Using the shared common operating picture and whiteboard like annotations (brush-marks, highlighting, and notes), CPOF helps commanders communicate their intent and synchronize tactical actions on the battlefield.[62]

CPOF also has powerful military mapping capabilities, such as terrain analysis tools that can manipulate and measure aspects of the terrain based on the user's inputs. Analysts use the OAKOC (observation and fields of fire, avenues of approach, key terrain, obstacles, cover and concealment) variable to assess the military aspects of the terrain.[63] Additionally, requests for information submitted to terrain analysts and geospatial engineers at higher command echelons help analysts fill gaps in current intelligence. These personnel have the capability to create computer generated models that include cross-country mobility, lines of communication, vegetation type and distribution, surface drainage and configuration, surface materials, subsurface materials, obstacles, infrastructures, and flood zones.[64] Analysts in the intelligence section also have access to the Digital Common Ground System- Annex (DCGS-A) used to analyze geospatial imagery. DCGS-A's terrain analysis tools analyze intervisibility lines to detect cover and concealment areas, and analyze cross-country mobility to identify travelable routes and key terrain features.[65]

Typically, an Air Force Staff Weather Officer (SWO) provides the weather analysis. Military aspects of weather include visibility, wind, precipitation, cloud cover, temperature,

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[61] Scott R. Gourley, "Mission Command Applications 'Ebb and Flow' With Army's Network," *Army Magazine*, March 2013, access February 15, 2018, http://www1.ausa.org/publications/armymagazine /archive /2013/03/Documents/Gourley_March2013.pdf, 32-36.

[62] Ibid.

[63] US Army ATP 2-01.3 (2014), 3-6.

[64] US Army National Guard, *Battle Staff Guide A Reference Tool for Commanders and Battle Staffs* (Fort Leavenworth, KS: Battle Command Training Center, 2010), 270.

[65] Joey Cheng, "Army Intelligence System Gets New Geospatial Tools," *Defense Systems*, April 9, 2014, accessed February 15, 2018, https://defensesystems.com/articles/2014/04/09/army-dcgs-a-esri-geoint-tools.aspx.

humidity, and atmospheric pressure (as required).[66] Weather and terrain analysis is continuous. Analysts examine how the terrain and weather can affect military operations as well as the effects and potential changes military operations will have on the environment, including traffic patterns, agricultural changes, and refugee movements. Analysts must consider the existing situations as well as conditions forecasted to occur during mission execution. During the MDMP, analysts develop an understanding of the terrain and weather and make products for the intelligence estimate. These products such as MCOO, terrain effect matrices, and terrain assessments, weather forecast charts, weather effects matrices/operational impacts charts, light and illumination tables, and weather estimates support future planning efforts.[67]

During terrain and weather analysis, an analyst starts by reviewing available information provided from the higher headquarters. The analyst reaches out to other organizations including the National Geospatial-Intelligence Agency for existing imagery. The analysts work with terrain analysts and engineers at higher headquarters and within their unit to gather detailed information on areas relevant to the mission. Bridge weight classes along major supply routes and possible wet gap crossing sites are examples of these information requests. Using CPOF or DCGS-A, the analyst stacks the terrain overlays to gain a better understanding of the terrain. Lastly, the analyst gathers the historical, current, and predicted weather data from the Air Force SWO and assesses how the weather will change the terrain and OAKOC variables. The ultimate goal is to determine how the terrain and weather will affect friendly and enemy operations. The operational environment functions as a system and requires analysts to use a system thinking process to examine how variables of a system function and affect each other as a part of a greater whole.[68]

[66] US Army, ATP 2-01.3 (2014), 4-18.

[67] Ibid., 1-4.

[68] US Department of the Army, Army Techniques Publication (ADP) 5-0.1, *Army Design Methodology* (Washington, DC: Government Printing Office, 2015), 1-7.

In his book *The Logic of Failure*, Dietreich Dorner explains that the humans are linear thinkers and have issues analyzing complex systems.[69] Robert Jervis' systems effects theory asserts that you cannot do just one thing in a system— whatever you do will have multiple effects.[70] For these reasons, human planning and decision making processes can go awry if planners ignored the possible side effects and long-term interactions.[71] Analysts must consider the innumerable, interrelated subsystems of terrain and weather and think terms of these interrelations. When there is a significant time span between the action and reaction, it is hard to correlate cause and effect. When analysts reevaluate the system they do not spend adequate time to fully evaluate long-term effects or have a tendency to think of isolated cause-and-effect relationships. The experiments presented in *The Logic of Failure* illustrate that small changes can have logical, but unperceived rippling effects throughout the environment.

Analysts must understand that as one element in the system changes, multiple effects manifest throughout the system. Analysts cannot assess terrain independent of weather conditions. Analysts consider weather conditions alongside terrain, because weather changes aspects of the terrain. For this reason, terrain and weather analysis are inseparable. For example, the weather data may forecast five inches of rain in two hours. The rain will flood the fields in agricultural areas and make some rural roadways impassible. People will then reroute to larger roads thus increasing traffic congestion on main supply routes. Congestion increases the time required for delivery of resupply and causes it to arrive during hours of darkness. If there is no lighting at the delivery site, due to the threat environment, the soldiers will wait until sunrise to offload the supplies. In this example, the rain caused unexpected effects that delays a unit's

[69] Dietrch Dörner, *The Logic of Failure: Why Things Go Wrong and What We Can Do to Make Them Right* (New York: Metropolitan Books, 1996), 5.

[70] Robert Jervis, *System Effects: Complexity in Political and Social Life* (Princeton, NJ: Princeton University Press, 1998) 64-65.

[71] Dörner, *The Logic of Failure*, 5.

mission by 24-48 hours. This example illustrates why analysts must use a systems thinking approach to analyze how terrain and weather impact military operations. In order to gain a better understanding of the system, analysts examine the terrain by overlaying multiple terrain models. Incorporating weather aspects when assessing the terrain, adds additional layers of technical data whose effects are not easily discernable.

The interconnectedness of the operational environment presents challenges for human cognition. Humans, using their System 1 thinking, often try to simplify complex problems instead of deliberately understanding the system as a whole. Humans typically revert to mental modes or shortcuts to understand the unfamiliar complexity of technical data. The challenge with System 1 thinking is its insensitivity to the quality of evidence it considers when making judgments.[72] Psychologist Philip Tetlock explained in his book *Superforecasting: The Art and Science of Prediction* that humans have an explanatory urge and compulsion to explain why things occur. He asserts that humans quickly draw clear and confident conclusions when one sounds reasonable and discount that there could be many other logical conclusions. For example, when the stock market rises and falls, journalists are quick to associate it with something in the news for that day. Actually, no one can pinpoint a specific reason it rose, since it could be due to a combination of hundreds of reasons.[73] Intelligence analysts face similar cognitive challenges. Specialized analysts from outside sources provide much of the initial imagery and detailed, so it is challenging to understand holistically. Furthermore, more imagery is being collected than human analysts can examine, leaving a great deal of useful data unexploited.[74]

[72] Philip E. Tetlock and Dan Gardner, *Superforecasting: The Art and Science of Prediction* (New York: Crown, 2015), 35.

[73] Ibid,. 35-37.

[74] Colin Clark, "Cardillo: 1 Million Times More GEOINT Data in 5 Years," *Breaking Defense*, June 5, 2017, accessed December 23, 2017, https://breakingdefense.com/2017/06/cardillo-1-million-times-more-geoint-data-in-5-years/.

Analysts also face biases when conducting terrain and weather analysis. When analyzing the effects to military operations, it is common to think in terms of friendly equipment and capabilities. Although the specific capabilities of the enemy equipment are known and different from friendly equipment, intelligence analysts often rely on the other staff sections to assist with reverse IPB. "Can a tank cross that bridge?" Questions such as this one reinforces the fact that our analysis is often biased to the capabilities of friendly equipment. Although the staff understands that the enemy's equipment is different, friendly equipment is familiar and leaves the individual with an availability bias. Relying on other staff section's input could cause an analyst to unknowingly discount or discredit any differences or advancements in the enemy's capabilities. Machine and deep learning forms of artificial intelligence may assist analysts faced with these challenges.

The IC is developing artificial intelligence options to deal with massive data challenges. The Department of Defense's (DOD's) Algorithmic Warfare Cross-Functional Team (AWCFT), also known as Project Maven, is exploring ways the military can use deep learning and neural networks to extract insights from intelligence data. Project Maven focuses on identifying and classifying objects detected from small-unmanned aerial vehicles. The Project Maven team spent six months developing an object recognition algorithm. The team deployed to the Middle East in December 2017 to test their newly developed artificial intelligence algorithm's ability to identify objects in full motion video footage from the ScanEagle reconnaissance drones.[75] Initially, the artificial intelligence correctly classified objects such as cars, people, and types of buildings with a sixty percent accuracy rate. During the testing, an analyst observed the algorithm in action and identified when the computer mischaracterized an object, thus helping it learn. This is a practical example of human-machine teaming. The team continuously assessed the computer's reporting

[75] Andrew Foerch, "Operationalizing Project Maven AI Algorithms Make Their Combat Debut," *Trajectory*, January 12, 2018, accessed February 25, 2018, http://trajectorymagazine.com/operationalizing-project-maven/.

and conducted a handful of software updates to make the algorithm better. With just a few days of testing, the algorithm improved to an eighty percent accuracy rate.[76]

The Maven algorithm paired with a correlation and geo-registration application called Minotaur to display the location of the items classified by the Maven algorithm onto a tactical network. "Maven has the algorithm which put boxes on the video screen, classifying an object and then tracking it. Then using Minotaur, it gets a geo-registration of the coordinates, essentially displaying the location of the object on a map."[77] Minotaur's speed in correlating massive information sets, capability to maintain track histories, and seamless exportation of data into actionable intelligence is widely known.[78] Together, the technology provided a greater understanding of the operational environment by showing where the identified objects from the ScanEagle feed were located in real time. These objects and their locations, in theory, could then populate onto the MCOO to verify activities around key terrain or friction points.

The ability of this technology to recall and track the items it has identified, and use that information to extrapolate patterns greatly exceeds the capacity of the human analyst alone. This example highlights the potential for artificial intelligence to assist the intelligence analyst determining changes in traffic patterns, personnel movements, and subtle changes to the operational environment that a human analyst might miss. The technology could incorporate natural language user interface, so that the analysts and machine could communicate. For instance, similar to Amazon's Alexia or Apple's Siri, when planning a mission, the analyst could ask questions and request recommendations. For instance, the analyst could say, "Please show me

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[76] Marcus Weisgerber, "The Pentagon's New Artificial Intelligence is Already Hunting Terrorists," *Defense One*, December 21, 2017, http://www.defenseone.com/technology/2017/12/pentagons-new-artificial-intelligence-already-hunting terrorists/144742/?oref=d%20topstory&utm_source=RC+ Defense +Morning+Recon&utm_campaign=%205746cf36f5-EMAIL_CAMPAIGN_2017_12_22&utm_ medium=email&utm_term=0_694f73a8dc-5746cf36f5-85513145.

[77] Ibid.

[78] Sharon Anderson, "Delivering Decisive Understanding to the Commander," *Don Cio*, April-June 2016, accessed February 15, 2018, http://www.doncio.navy.mil/mobile/ContentView.aspx?ID= 7899&TypeID=21.

the fastest route for an M1A2 tank to travel from Point A to Point B." Artificial intelligence would then show the estimated time and alternative routes in a fraction of the time it would take an analyst to conduct a route assessment. The natural language user interface helps the analyst derive meaning from the data.

Artificial intelligence could incorporate information from many sources including the weather forecast, knowledge of past traffic patterns, current reporting of traffic accidents in the news, etc. The algorithm adjusts and learns the analysts' concerns when asked more questions. Therefore, the human-machine teaming provides a better solution that just the analyst or just the machine alone. The ability to work together and for the analyst to tap into the memory and patterns exploited by the machine provides a greater understanding of the operational environment and assists analysts in identifying how the terrain and weather effects friendly and enemy operations. Additionally, the algorithm provides continuous systems analysis as it constantly pulls data from sources and learns how the environment is changing. The computing ability to analyze all aspects of the operational environment independently and understand how each affects the system, far exceeds human ability. Human-machine teaming can help minimize information overload. Artificial intelligence's capability to understand the unique differences in each model of vehicle and specialized piece of equipment helps minimize the biases of analysts who often create calculations based their knowledge of friendly equipment.

Conclusion and Recommendations

Intelligence fuels the commander's understanding of the operational environment and serves as the basis upon which the commander anticipates opportunities to gain a relative advantage over the enemy. IPB is the process analysts use to develop situational understanding of the battlefield. IPB identifies significant characteristics of the enemy, terrain, weather, and civil considerations that are relevant to the mission. Analysts have issues deriving meaning from the growing amount of information available in today's operational environment. Reading speed, attention to detail, and workload influence are a few of the factors that influence the amount of information the human brains can process.[79] Experiences, training, and intuition when judging the value of information can bias analysts' judgments. Artificial intelligence is a viable tool to help minimize the effects of information overload and cognitive bias in intelligence analysis. Machine and deep learning helps analysts by sifting through massive amounts of data and extrapolating patterns.

Two practical examples, explored through scenario development, illustrate ways to incorporate into the IPB process. Artificial intelligence can assist with building link diagrams and conducting terrain and weather analysis. Facial recognition, natural language processing, machine and deep learning can help analysts build link diagrams by examining reports, creating nodes, organizing links, and continuously refining the product. Machines can quickly process data and analyze information. This automation reduces the amount of information analysts must manually process thus reducing information overload. Machine and deep learning avoids common human bias, such as the tendency to forget foreign names, make calculations based on friendly equipment, or disregard information that does not meet preconceived expectations.

Advances in artificial intelligence continue at a rapid pace. The IC should view these artificial intelligence developments as viable options for reducing the effects of information overload and cognitive bias in intelligence. Human-machine teaming draws on the strengths of machines to rapidly sort through large sets of data and extrapolate significant data. Humans use this data to derive meaning and intelligence from the available information. The conversational dialogue between the machine and analyst is key to drawing significance from the data. Analysts are the conduit for incorporating relevant intelligence into the planning process to ensure the commander maintains situational understanding of the operational environment.

Human-machine teaming offers many benefits and adds control measures that reduce risks. Human-machine teaming and collaboration is valuable because it allows machines to help

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[79] *AI Business*, "Solving the Data Crisis with a Military Intelligence Approach to AI," November 16, 2017, accessed February 15, 2018, https://aibusiness.com/essence-intelligence-military-ai/.

humans make better decisions. Artificial intelligence processes data and analyzes information at a fraction of the time required for a human. Human oversight and correcting algorithm errors allows the machine to learn which reduces the risk of inaccuracy. Human-machine teaming also reduces the risk of atrophy to human analytical skills and total reliance on artificial intelligence.

Field Manual (FM) 6-0 uses the model in Figure 6, Achieving Understanding, to explain the progressive transformation of data into understanding. Successful commanders make timely and effective decisions based on applying judgment to available information and knowledge. Throughout the planning and conduct of operations, the commander seeks to build and maintain situational understanding. The staff and subordinate units support the commander in developing understanding. The staff and subordinate units process data and analyze information that leads to knowledge, which analysts judge to gain understanding as it relates to the operational environment.[80]

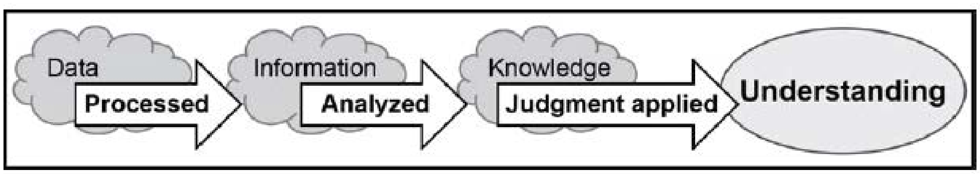

Figure 6. Achieving Understanding. US Department of the Army, Field Manual 6-0, *Commander and Staff Organization and Operations* (Washington, DC: Government Printing Office, 2014), 3-1.

Figure 7 illustrates how human-machine teaming integration into the "Achieving Understanding" process. Machines process data and analyze information quickly and indiscriminately, which helps analysts apply that knowledge to make judgments. The analysts apply meaning to the patterns extrapolated by artificial intelligence and evaluate resulting implications for operations. The analysts' experiences, training and expertise, and knowledge of the mission help the analysts make determinations on how and why the information matters. Analysts incorporate knowledge into the planning process to fuel the commander's situational

[80] US Department of the Army, Field Manual (FM) 6-0, *Commander and Staff Organization and Operations* (Washington, DC: Government Printing Office, 2014), 3-1-3-2.

understanding. Synthesized knowledge enables the commander to synchronize actions in time, space, and purpose.

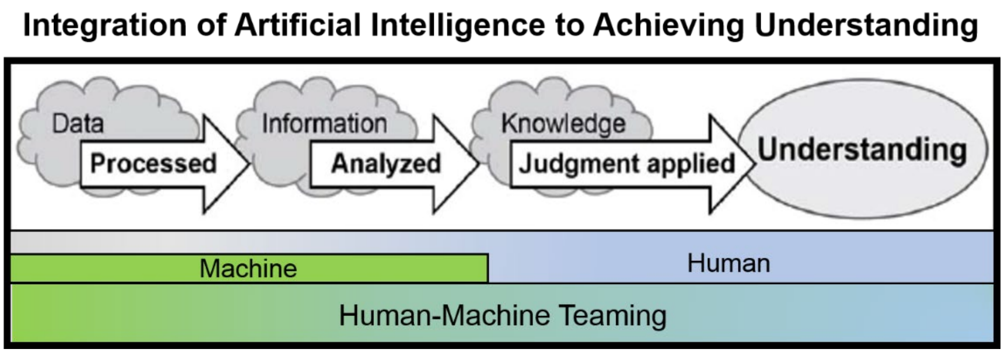

Figure 7. Integration of Artificial Intelligence to Achieving Understanding. US Department of the Army, Field Manual 6-0, *Commander and Staff Organization and Operations* (Washington, DC: Government Printing Office, 2014), 3-1, modified by author.

Artificial intelligence is a cost-effective solution to tackle information overload and cognitive bias challenges in military intelligence analysis. Creating artificial intelligence is less time consuming and cheaper than hiring and training the number of analysts required to sift through the massive amounts of information available in today's operational environment. Project Maven demonstrates that ideas can quickly transform into functional algorithms within a matter of months. Proper allocation and prioritization of funds for specific artificial intelligence purposes is key to successful artificial intelligence integration.

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