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In 1958, Senator Lyndon B. Johnson called the US to action after the Soviet Union successfully launched the first satellite into space. Johnson recognizing the importance of the event declared, "Control of space means control of the world." Thus, the space race between the Soviet Union and the United States began; likewise, another race is underway to be the first nation to harness the technological advantages of artificial intelligence (AI) fully. For the US military to maintain a premier force around the world, it must lead in understanding, harnessing and implementing AI throughout the Joint Force. Failure to do so will result in outdated systems and equipment that fails to defend the US and its interests around the world.

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MASTER OF MILITARY STUDIES

Science Fiction to Reality: leading in artificial intelligence

SUBMITTED IN PARTIAL FULFILLMENT
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Major Christopher D. Mollet, USMC

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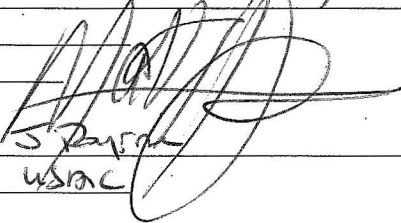
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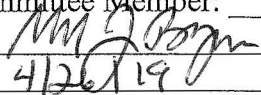
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Executive Summary

Title: Science Fiction to Reality: leading in artificial intelligence

Author: Major Chris Mollet, United States Marine Corps

Thesis: In order for the United States military to maintain a premier force around the world, it must lead in understanding, harnessing and implementing the advancements of artificial intelligence (AI) throughout the Joint Force. The failure to adopt AI will result in costly outdated systems and equipment that fails to defend the US and its interests around the world.

Discussion: In 1958, then-Senator Lyndon B. Johnson called the United States to action after the Soviet Union successfully launched the first satellite (Sputnik) into space. Unlike other prominent leaders of the time, Johnson recognized the importance of this event by declaring “Control of space means control of the world.” These events would set in motion a space race between the Soviet Union and the United States, the premise of which was two-fold: first, get the country rallied toward the moral imperative of participating in the space race, and second, develop advancements in technology to win the race to the moon. The space race led to amazing accomplishments to include the first man landings on the Moon.

However, unbeknownst to much of the world, a race similar to that of the space race has started and is gaining significant momentum around the world. This race is not to the moon, but in being the first nation to harness technological advantages of AI throughout all of society. “The United States won that [aspect of the space] race ... by inspiring the next generation of scientists, technologists, and optimists,” argues John Allen and Amir Husain of SparkCognition, a leading Artificial Intelligence (AI) company.

Furthermore, the main competitors in this race are not the United States and the Soviet Union, but instead the United States and China. Likewise, just as the original space race had high stakes, so too does this race, with the victor potentially upsetting the equilibrium of economic and military power around the world. Ironically, Russian President Vladimir Putin, echoing Johnson’s declaration made six decades earlier, declared the importance of AI by asserting, “whoever reaches a breakthrough in developing artificial intelligence will come to dominate the world.”

Conclusion: AI is literally on the cusp of exploding into every aspect of life, with the US military rapidly positioning itself to reap its benefits. Any suggested implementation of AI made throughout this study are just the start of how immensely AI will benefit the Joint Force. As the Joint Force leads in incorporating AI throughout the force, the US military’s supremacy around the world will continue.

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Preface

This research topic was prompted by a good friend Major Zach Lucas (USMC). When I told him of my original idea of writing on the lack of realistic logistics training within the military occupation of Logistics, he bluntly told me it sounded boring. Fortunately, he asked if I knew anything about Artificial Intelligence (AI) and I responded with “You mean Terminator.” After chuckling, he said I should consider writing on AI instead. He further encouraged me to watch the Netflix documentary “AlphaGo,” which covers the encounter between an artificially intelligent computer and the Korean world champion of the ancient game of "Go." Watching this film made my mind spin thinking of the possible military uses for AI. My mind is still blown that science fiction is actually coming to life. For this, I am thankful for your nudging Zach. I hope this paper does the subject justice.

Within recent years, AI has become a technological powerhouse that is influencing every sector of society. No area of life is safe from this agent of change. From science fiction movies such as the *Terminator* movies, contemporary AI usually receives negative headlines for speaking of the imminent dangers at the hands of AI. These media stories and movies have created a gap in the awareness and trust of AI in society; providing a disservice to the prospects of how AI adds value to our lives. This research looks to provide an optimistic and balanced exploration of AI, one contrary to the negative publicity in the media. By gleaning from both the private and public sectors of AI, this research explores how AI will enhance and impact the US military capabilities. While I strove to write this research study to provide a foundational understanding of the topic, it is meant mainly to intrigue readers to want more. I am indebted to my Master of Military Studies advisor, Dr. Matthew Flynn for helping me scope my material appropriately, and for allowing me the liberty to explore the topic in order to find my footing.

I hope this paper is both enlightening and thought-provoking. The many hours spent on researching and writing came at the cost of lost time with my lovely wife Shawna and my children, Isaac, Aleah, and Aidan. I am grateful for their patience and sorry for all the times I had to say, “no, I cannot play with you right now; I have to go to school and write a paper.”

Introduction

In 1958, then-Senator Lyndon B. Johnson called the United States to action after the Soviet Union successfully launched the first satellite (Sputnik) into space.¹ Unlike other prominent leaders of the time, Johnson recognized the importance of this event by declaring, “Control of space means control of the world.”² These events would set in motion a space race between the Soviet Union and the United States, the premise of which was two-fold: first, get the United States to accept the moral imperative of participating in the space race, and second, develop advancements in technology to win the race to the moon. The space race led to amazing accomplishments to include the first man landing on the Moon.³

Today, and unbeknownst to much of the world, a race similar to that of the space race has started and is gaining significant momentum around the world. This race is not to the moon, but instead being the first nation to harness the technological advantages of AI throughout all of society. “The United States won that [aspect of the space] race ... by inspiring the next generation of scientists, technologists, and optimists,” argues John Allen and Amir Husain of SparkCognition, a leading Artificial Intelligence (AI) company.⁴ That comment implies that something similar must happen now to win the AI race.

Furthermore, the main competitors in this race are not the United States and the Soviet Union, but instead the United States and China. Likewise, just as the original space race had high stakes, so too does this race, with the victor potentially upsetting the equilibrium of economic and military power around the world. Ironically, it would be Russian President Vladimir Putin, echoing Johnson’s declaration made six decades earlier, who captured this imperative by declaring the importance of AI by asserting, “whoever reaches a breakthrough in developing artificial intelligence will come to dominate the world.”⁵ This magnification of AI has fueled the

idea that AI is this generation's "Sputnik moment," thereby raising the stakes for both the victor and loser.⁶

The present day finds the US Joint Force in a similar situation as in the days of the pre-space race. The services are emerging from the longest stretch of armed fighting the nation has ever seen. This prolonged period of conflict has been associated with the military losing ground on the technology front, a fact contributing to the weakening of the readiness of an aging Joint Force infrastructure and capabilities.⁷ As a result of this miring in prolonged conflict, an opportunity has been provided to China to seize the initiative in developing advances in its military technological capabilities, an opportunity that China is striving hard to capitalize upon.

China released its national strategy on AI in 2017 titled, "New Generation Artificial Intelligence Development Plan."⁸ China views AI strategy as a "major strategic opportunity," brought to fruition through a purposeful synchronization of both private and public industries through a whole-of-government approach toward AI expansion.⁹ More specifically, China's development of AI is striving to level the military playing field with that of the United States.¹⁰ Gains made by China will present the United States with a complex threat environment. This threat environment was cited in the 2016 Marine Corps Operation Concept (MOC), which calls for addressing the threat of AI through a blend of 21st-century warfighting technologies to enable the force to function in a more distributed posture.¹¹ A future fight with China will be determined by the ability of the Joint Force to leverage emerging 21st-century technology such as AI.¹² Therefore, the US military needs to adjust focus and fully appreciate what AI offers in terms of military capabilities.

The need to understand and act on AI is not too dissimilar from the need that once impacted the pursuit of space exploration. Both have had naysayers arguing it will not work or

that it is too dangerous. Similarly, fears also circulate around AI. For instance, industry technology leaders such as Elon Musk, founder of Tesla, Bill Gates, founder of Microsoft, and Steve Wozniak, co-founder of Apple, all warn that AI advancements are a serious danger to humanity, even worse than nuclear weapons.¹³ James Barrat states in his book, *Our Final Invention*, that reckless pursuit of AI could put humanity in peril.¹⁴ However, these same technologists and scientists equally state that the tremendous technological breakthroughs AI will provide cannot be ignored. Some of these breakthroughs in AI are already changing the world and for the better in such areas as society, the economy, and governance.¹⁵

No matter the disagreement, the reality of AI for the Department of Defense (DoD) is that it is an enabler that will significantly change the way war is conducted. AI offers much more than weapons of destruction. Through the integration of AI, life and the defense of it are anticipated to dramatically change for the better. To learn and know what AI is will help make clear the truly infinite possibilities it can potentially provide and help advance gains for the US military as well.

When asking the average person what they think AI is, a usual response invokes scenes from Hollywood science fiction movies, like the 1984 release of “The Terminator,” where highly advanced robots are determined to kill off the human race. Though Hollywood has done a great job creating robot apocalyptic-type blockbuster films, these movies have created a gap in the awareness and trust of AI in society; this disservice has clouded the prospects of how AI adds value to our lives. Nevertheless, one does not have to be a computer scientist in the field of AI to see its influence on our every day lives. The quality of life today has improved as a result of AI enabled technologies such as online entertainment, medical diagnosis, E-commerce, autonomous

vehicles, and voice recognition software. These technologies are enhancing our lives in ways that 40-50 years ago were considered science fiction.

Moreover, countries around the world are having their own “Sputnik moments” when it comes to AI technology.¹⁶ One by one, countries are waking up to the reality that AI provides immense opportunities to enhance their societies and solve intractable problems that have plagued their countries for generations. What this awareness means in terms of military changes requires attention and does serve as a source of concern, however. Again, the call for AI awareness is one that must stop short of a call to war, yet to do this, one must be aware of the implications of the technology on warfighting.

Similar to the last space race, AI is inspiring both the private and government sectors in advancing AI technologies to never before seen levels, dwarfing those committed to space exploration. The military importance of the first space race is also repeating itself, with the US military recognizing the imperatives of AI advancements towards helping to maintain US military supremacy. AI advancements have driven the DoD to collaborate with the private sector to harness newly developed technologies and implement innovative AI capabilities throughout the Joint Force. This sudden importance of AI within DoD is also commensurate with a growing concern that our adversaries see advancements in AI as a way to level the playing field between themselves and the United States military. The United States won the last space race by means of inspiring a whole generation of scientists, technologists, and futurists to reach for the stars.¹⁷ The outcome of this new race will require the same if not more inspiration, a reach into the mind aided by machines seeking cognitive inspiration in the likeness of humanity. In this pursuit, one must guard against the Ghost in the Machine.¹⁸ This sobering calculation invites folly bordering

on trepidation as well as excitement pushing new discoveries. That equation must tilt to the latter.

The Next Step and Why

In order for the US military to remain a premier force around the world, it must lead in understanding, harnessing and implementing the advancements of AI throughout the Joint Force. AI is already changing the character of the future battlefield and the pace at which forces will face threats.¹⁹ The failure of the US military to adopt AI will result in costly outdated systems and equipment that fails to defend the United States and its interests around the world.²⁰ No other military in the world is better suited to fully incorporate the field of AI more than the US military. Much like the success of Americans pioneering space exploration, the Joint Force can harness the needed elements of AI to shape a needed advantage during wartime again. The following outlines what AI is, the current developments in AI, and where experts foresee this field going. The study then articulates how the US military could incorporate AI throughout different entities within the force, and what it may foretell for the future of the DoD.

Artificial Intelligence - What is it?

To understand how AI will revolutionize military actions, one must first understand what AI is. At the time of this writing, a Google search for “What is artificial intelligence” produced over 400 million results. Within those 400 plus millions of results were over 14 million videos and over 9 million books containing some aspect of artificial intelligence. The volume and depth of information on AI is immense, and going through all of that information, let alone understanding it, is an overwhelming task. Realistically, the ever-growing volume of information on the subject of AI is impossible for one human to grasp and understand. To help in this endeavor, a focus on academic work gets one past much of the whirlpool of information about

AI to both rarefy and elevate the analysis of AI. With this focus on this material, one can gain a useful and broad understanding of many of the needed components of this topic.

In order to begin, we must first understand what is intelligence? Intelligence, according to Merriam-Webster is "the ability to learn or understand or to deal with new or trying situations; or the ability to apply knowledge to manipulate one's environment or to think abstractly as measured by objective criteria."²¹ Artificial intelligence endeavors to create machines with the ability to emulate human intelligence and or human behavior through different computer programs.²² However, there is an agreement among AI professionals that AI falls short of human cognitive capabilities.²³ Nevertheless, the idea of artificial intelligence goes back to 1950 when Alan Turing, a pioneer of computer science, conceived "thinking machines" that demonstrate intelligence at the level of a human being.²⁴ For Turing, he saw the many benefits thinking machines would provide to society. The term, "artificial intelligence" was first used by John McCarthy and Marvin Minsky, American computer scientists who organized a popular computer science workshop at Dartmouth College in the summer of 1956.²⁵ During this workshop, experts discussed artificial intelligence and many of its facets.²⁶ Attendees to the Dartmouth workshop defined AI as, "making a machine behave in ways that would be called intelligent if a human were so behaving."²⁷ Further refining this definition in 1995, Stuart Russel and Peter Norvig, both leading computer scientists in the field of AI, state AI has four general areas:

(1) systems that think like humans (e.g., cognitive architectures and neural networks); (2) systems that act like humans (e.g., pass the Turing test via natural language processing; knowledge representation, automated reasoning, and learning), (3) systems that think rationally (e.g., logic solvers, inference, and optimization); and (4) systems that act rationally (e.g., intelligent software agents and embodied robots that achieve goals via perception, planning, reasoning, learning, communicating, decision-making, and acting).²⁸

According to these two definitions, AI is considered to be intelligent machines that demonstrate intelligence analogous to that of humans. Similar to humans, AI programs approach tasks by perceiving the requirement, developing a plan, making a decision, acting upon the plan, and then learning whether the results were valid.²⁹ This AI task analysis approach seeks to make decisions based on the findings of patterns or anomalies as it sifts through the vast sums of data. At the core of AI are systems that use computer processing power to achieve faster search results than humans. AI ultimately imitates superior intelligent behavior primarily via two-key components: data and algorithms.

The business dictionary defines data as, “Information in raw or unorganized form (such as alphabets, numbers, or symbols) that refer to or represent, conditions, ideas, or objects. Data is limitless and present everywhere in the universe.”³⁰ As per this definition, data or information is found anywhere and from any source. Data can be voice recordings, pictures, physical characteristics, colors, smells, fingerprints, temperatures, and more. The collection of different types of data are increasing with the use of devices such as computers, smartphones, and smart devices, which may automatically record, report and receive enormous quantities of data.

For an AI program to do anything it must have data, and lots of it, to synthesize. Fortunately, the modern world has made this material available and accessible. AI must have instructions to know how to interpret the data as well. These instructions are called algorithms and are just as essential to AI as is the abundance of information.

An algorithm as defined by the business dictionary is a:

Step by step procedure designed to perform an operation, and which (like a map or flowchart) will lead to the sought result if followed correctly. Algorithms have a definite beginning and a definite end, and a finite number of steps. An algorithm produces the same output information given the same input information, and several short algorithms can be combined to perform complex tasks such as writing a computer program. A cookbook recipe, a diagnosis, a problem-solving routine, are some typical examples of simple algorithms. Suitable for solving structured problems (amenable to sequential analysis) algorithms are, however, unsuitable for problems where value judgments are required.³¹

In short, AI algorithms are equivalent to mathematical formulas for computer programs to know how to solve problems and make decisions.³² An AI algorithm contains a set of step-by-step instructions given to the computer to complete a specified task or tasks. The algorithm informs the AI what to do with the data in order to produce specific results. To increase the demand for a variety of results, a number of algorithms have to be programmed and layered over each other. In short, AI evaluates a large volume of data using preprogrammed algorithms resulting in decisions at faster speeds than a human is capable of doing.³³

This enabling effect of AI to analyze large amounts of data by using sophisticated algorithms provides significant capabilities and will potentially get better as computer processing power becomes faster. Processing speed enables AI to replace and/or improve the efficiencies, speed, and accuracy of manual, repetitive, laborious, data-centric tasks that humans currently do.³⁴ The US military would be a prime candidate for AI to take over these essential but manual, repetitive, laborious, data-centric jobs that service members do every day. However, this is where the crossroads of current AI and the future of AI differ.

The current AI capability, *Narrow AI (ANI)*,³⁵ is excellent at executing algorithmic tasks.³⁶ With ANI, the solutions to a set of problems are through developed algorithms that have detailed processes for each task AI is assigned. This narrow view makes it difficult to generalize the data the algorithms are processing toward other results.³⁷ Simply put, ANI is intelligent enough to perform one or multiple narrow tasks, like playing chess, driving autonomous cars, voice recognition and is pervasive throughout our world.³⁸

The previous mention of a Google search for Artificial Intelligence is an excellent example of an ANI program.³⁹ Search engines have preprogrammed algorithms that search the world wide web when the user gives specific terms, words, or phrases. Once the search engine

has scoured Google's curated database of pre-defined results to match the specifications, the search results are displayed for the user to view. This was how a Google search for, "What is Artificial Intelligence," was able to produce 400 million results. However, not all results are useful and will require additional refinement by the user to find exactly what is being sought after. This process of gathering a pool of viable material is much faster than a human going to several libraries to look through the card catalogs of old, but still necessitates human input to complete the desired task.

Moreover, the scale and return of the search are just not possible without AI. With the proliferation of the internet in our everyday lives, ANI programs provide a clear benefit to assist us with resourcing and preferred filtering results when accessing the internet. The example of the search engine is just one-way AI is being incorporated into all areas where the use of specified algorithms and vast sums of data are being analyzed faster than humans are capable of doing. To process data is a valued human action that is better suited for AI to accomplish.

Additionally, the limitation of ANI is its narrow approach to executing specified tasks. This narrow approach avoids significant amounts of information that do not pertain to a specific task. According to John R. Allen and Darrell West of the Brookings Institute, ANI is only possible due to the massive improvements in storage systems, processing speeds, and analytic techniques that give ANI the tremendous capability and sophistication in analysis and decision-making.⁴⁰ However, to narrow human intelligence down to a step-by-step instruction does not represent the brilliance and intricacies of the human mind. The speed at which ANIs process information is more like an imitation of human cognition. This imitation pales in comparison to what a human brain is capable of doing in terms of raw cognition, no matter the ability of AI to

deliver thousands of results. Only humans can discern what result they want and why it matters, and what to do with it. ANI is not able to act human after all.

While computers cannot access data as a human can by taking in information from all five senses, the inability of AI to generalize the data necessitates the second and third versions of AI, *General AI (AGI)* and *Super AI (ASI)*.⁴¹ Theoretically, both AGI and ASI refer to an AI system that exhibits intelligent behavior as advanced or exceeding that of a human. Ben Dickson, software engineer and founder of Tectalks, describes AGI as a type of AI that can receive, process, and simplify information and data coming from its surroundings, just as a human would.⁴² Humans can make decisions while simultaneously sifting through a range of continuous thoughts and constant reception of information taken in from our senses. Though computers may be able to process data faster, they cannot think abstractly, plan, and solve problems at a general level.⁴³ According to Nick Bostrom in his book *Superintelligence*, if and when ASI comes, it is expected to dramatically exceed the cognitive performance of humans in virtually all domains of interest.⁴⁴ An ASI would be able to be cognitively aware of its existence and surroundings, and be able to think exactly like humans, but faster.⁴⁵

The advent of AGI is expected to bring about a new era of computer self-awareness or an “intelligence explosion.”⁴⁶ A notable mathematician whose work decrypting the German Enigma ciphers foreshadowed the modern computer age, Irving John Good, first speculated in 1964 that AGI will usher in a massing of intellect, or an intelligence explosion, leaving man’s intellect far behind.⁴⁷ Good explains that:

As computers increase in power, it becomes possible for people to build a machine that is more intelligent than humanity; this superhuman intelligence possesses greater problem-solving and inventive skills than current humans are capable of. This superintelligent machine then designs an even more capable machine, or re-writes its own software to become even more intelligent; this (even more capable) machine then goes on to design a machine of yet greater capability.⁴⁸

In a nutshell, an intelligence explosion is an artificially intelligent system that is both self-aware, self-improving, and has the necessary computing power to achieve concentrating acuity to solving a myriad of problems at the speed of immediacy. Furthermore, if advanced AI does come, it is expected that AGI will come first, spurring the advent of ASI shortly thereafter.

Achieving AGI and ASI are proving extremely difficult. Though computer scientists have been able to create various complex sets of algorithms to perform a myriad of tasks, they have not been able to create an AI that is aware of itself and makes decisions according to its own needs. The limits of current technology seem to separate the ANI of today from the much more difficult challenges that AGI and ASI are expected to achieve.⁴⁹ Also, attempts towards increasing ANI abilities have failed to reach AGI or ASI performance.⁵⁰ Moreover, neither AGI or ASI are speculated to occur for decades, or at least until a technology leap can occur that would make this possible. The soonest researchers expect this to happen is 2030.⁵¹

With ANI presently being the primary version of AI, the need becomes understanding where ANI is projected to be used in the future. ANIs consist of subcategories such as the internet of things, machine learning, and autonomous machines. These subcategories will be further explored in both their present state and projected military uses.

The Connection of Things

The advent of the internet, as well as the devices that connect to it, have catapulted advances in AI technology like never before. With more devices connecting to the internet every second, the resulting data creation is growing exponentially.⁵² According to Statista, a statistics portal online, over 74 billion devices worldwide will be connected to the internet by 2025.⁵³ According to *Forbes* magazine, over 4,800 devices are currently being connected to the internet every minute, which is expected to increase to over 152,000 by 2025.⁵⁴ Such devices as

smartphones, smart televisions, smart watches, smart thermostats, smart lights, and smart refrigerators are ‘smart’ because they connote the ability to access the internet.⁵⁵

With a plethora of devices connecting to the internet, connectivity delivers the potential for users to have more control over their daily lives via the Internet of Things (IoT).⁵⁶ Mor Rahimi, a marketing and business developer in the area of technology innovation, describes IoT as, "...the ability to turn any THING (a good/ object/ machine/ appliance/ building/ animal/ plant...) into a smart object. This smart object will, in turn, be able to connect, monitor, manage, control, search and more without the necessity for human intervention."⁵⁷ For Rahimi, the ability to make any object smart provides tremendous solutions to our everyday lives.

In his book, *The Sentient Machine*, Amir Husain describes IoT as an AI that is made up of a growing sophisticated and intelligent network of programs. This network controls our devices through data processing and enhanced sensors which are routinely making decisions for the user.⁵⁸ Decisions are based on preselected choices such as turning on lights, setting the thermostats, turning on music, or alerting the authorities if a suspected burglary is in progress. Husain goes on to state there will be three waves of IoT that society will go through.⁵⁹ The first is considered the “Measuring and Tracking” wave. Husain states we have been in this wave for a while with the increase of personal technologies, like the smartwatch which acts as a biometrics tracker, personal assistant, and mobile phone. Husain adds that the business sector has been leading in this wave with more and more equipment embedded with sensors to measure, track, and enhance system performances.⁶⁰

The second wave of IoT is “Modeling and Predicting.”⁶¹ Husain states we are on the cusp of this wave occurring with wearable technology going further than measuring and tracking biometrics, to acting as a personal doctor providing full diagnosis and recommendations for a

user's health. Husain states more sophisticated technology in the area of sensors and different data collection methods need to be installed in these devices before this wave is seen. Husain gives an example of the second wave capability by explaining that smartwatches will advance to the point that they will monitor what the wearer is eating, level of exercise, cholesterol level, and, in turn, notify the wearer of potentially life-threatening conditions based on family history.⁶²

In the business world, the machines will not just monitor, but will also be able to conduct predictive analysis on equipment based on different metrics like temperature, vibrations, or extreme usage. These machines will not just sense what is wrong but be able to react to analyzed results, making corrections where required. Much of this functionality is already occurring around the world. Such examples are the wi-fi connected iRobot's Roomba vacuums, construction survey drones, and Amazon's smart warehouses.⁶³

A current example of this second wave within the military is the communication, navigation, and identification (CNI) suite found on the F-35 Joint Strike Fighter.⁶⁴ The F-35's CNI suite includes an automated fault detection and isolation function that can sense any malfunctions with the aircraft and then send the information to maintainers via a high-speed data link.⁶⁵ According to Lockheed Martin, F-35s CNI feeds into a broader system called the Autonomic Logistics Information System (ALIS).⁶⁶ With the F-35 having many of its components digitalized, much of the information concerning the health and maintenance of the aircraft can be transmitted instantly to the support personnel and commanders on the ground.⁶⁷ ALIS integrates current operations, maintenance requirements, aircraft prognosis with real-time supply chain support, and technical repair data.⁶⁸ Realistically, with ALIS, an identified malfunction on the aircraft can be sent to the technicians on the ground, who pass the requirement to the supply chain, which in turn identifies the inventory location of the needed

repair part and sends the part to the required location. By the time the aircraft has reached the hanger, the maintenance team is standing by with the repair part en route. This is different from the traditional repair cycle, which usually starts with an identified malfunction upon landing, then requires the maintenance team to spend hours troubleshooting the malfunction to isolate and assess for potential solutions. The traditional repair cycle results in inefficient use of time and money, therefore increasing downtime and results in substandard operational performance.⁶⁹

The third wave is titled, “A Trillion Fully Autonomous Devices.”⁷⁰ In this wave, highly intelligent AI algorithms will create a complex network of sensors to respond to real-world situations, responses that will be able to reproduce, distribute, and control fully autonomous devices such as never been seen before.⁷¹ This wave will likely be most advantageous for industries such as agriculture, law enforcement, and military defense.

A current private industry example of this push is the idea of “smart farms.”⁷² According to Meghan Brown, a contributor for the online site *Engineering.com*, smart farms involve the interconnection of a complex network of autonomous robots, drones, and sensors communicating with each other all while being connected via the IoT. The idea is for the network of robots, drones, and sensors to be able to till the soil, plant the seeds, water the crops, fertilize the crops, monitor the health of the crops, and then harvest the crops with minimal human intervention. Moreover, smart farms are designed to be more efficient than humans and are calculated to increase the yield capacity of crops without destroying the environment.⁷³ Much of the technology for the smart farm idea already exists and is in experimental stages or being used today. For example, the leading company in drone technology, Da Jian Innovations (DJI), has created agriculture drones that can monitor a crops’ sickness and disease, moisture levels, and deliver pesticides or fertilizer where needed most. According to DJI, the Agras MG-1 operates

“automatically, semi-automatic or manual.”⁷⁴ These agriculture drones collect data from crops through different attachments containing sensors or cameras that communicate information back to the farmers via the IoT.

The smart farm is just one example of how both current and future AI technologies are close to achieving Husain’s third wave, which in turn opens up tremendous opportunities for better efficiency and utilization of limited resources to support more people with less damage to the environment.

This third wave again has tremendous implication for use by the US military for providing real-time results. Third wave technologies would save an enormous amount of time and money, and decrease the downtime that results in efficient operational performance. However, no autonomous system as cited by Husain currently exists in the military. Husain does give an example of the next generation of military weapons, such as thousands of autonomous hunter-killer drones.⁷⁵ These hunter-killer drones that are mentioned in Paul Scharre’s book, *Army of None*, are currently being researched, developed, and advanced.⁷⁶ More on autonomous drones and robots will be discussed later in the autonomous section. Nevertheless, the importance of the many applications applied to the IoTs is limited only to the imagination of implementation to the domain of IoT (See figure 1 below).

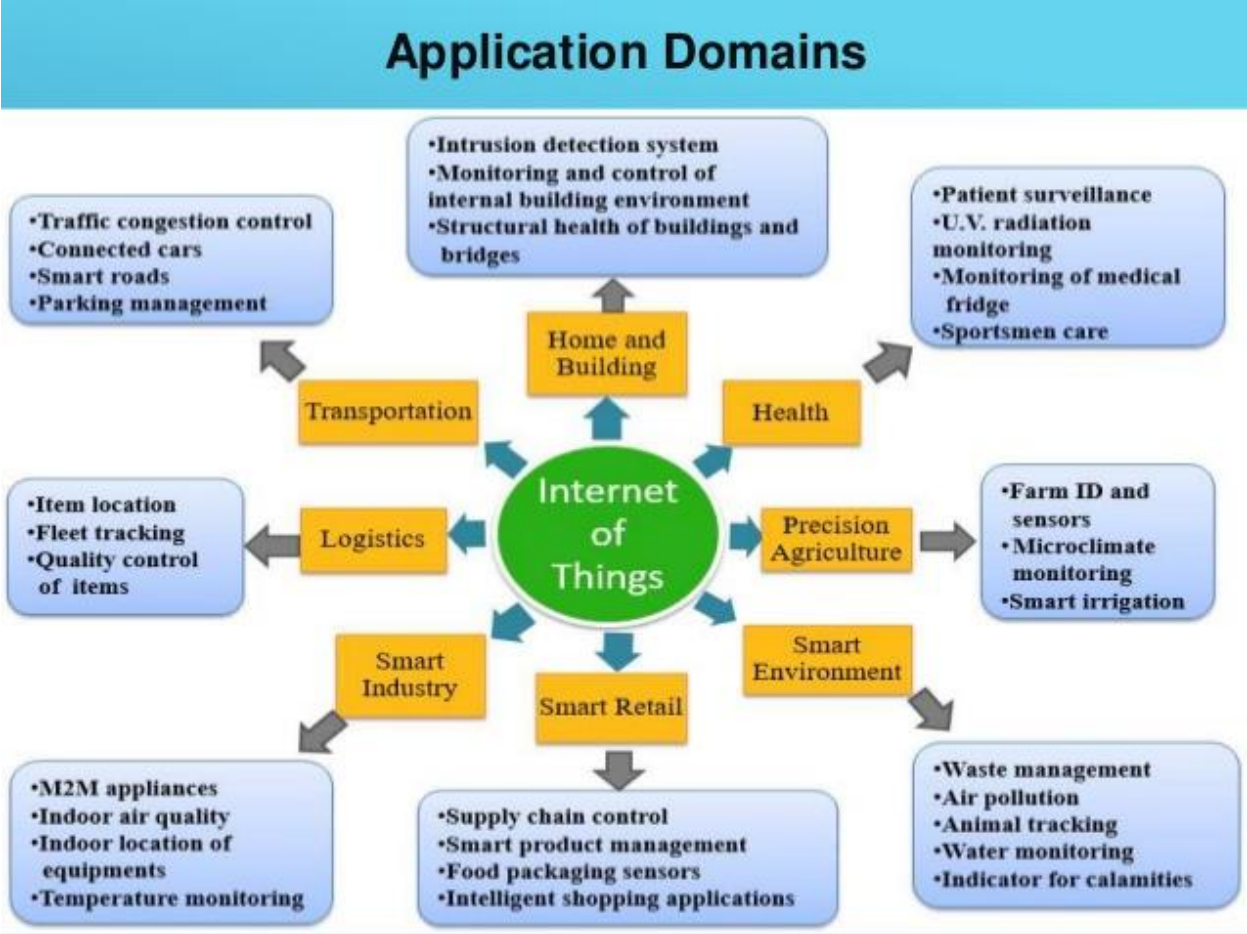


Figure 1: **Internet of Things (IoT) Application Domains**

Source: Aasheesh Tandon, Emerging Applications Perspective for Internet of Things, ICTCS '16: Proceedings of the Second International Conference on Information and Communication Technology for Competitive Strategies, Published March 20, 2016, <https://www.slideshare.net/Blessingdon7/emerging-applications-perspective-for-internet-of-things/4>.

The IoT has spurred greater creativity and connectivity for users than ever before. The possibilities that IoT provides users are endless, with more and more startups jumping on board providing goods and services. In his book, *AI Superpowers*, Kai-Fu Lee states that companies like Amazon, YouTube, and Google are just the start of companies the internet will help to create. Lee goes on to state that the internet has a significant grip on our wallets as well as our

attention, and this grip will drive us to pursue more advanced technologies, some of which we did not know we wanted or needed in our lives.⁷⁷

According to Lee, the grip on our attention is evident every time we find ourselves endlessly surfing the internet, clicking on link after link because something we saw enticed us to continue clicking.⁷⁸ To Lee, internet companies like YouTube, Facebook, and Amazon use what he calls “internet AI” which use algorithms to suggest additional content or products based on a users’ preferences collected while using that particular online site.⁷⁹ Every online company is collecting personalized digital data through specific data collection algorithms, says Lee. Each click creates digital data: for example, the amount of time spent watching a video, products purchased, searches conducted, and even those featuring ‘likes.’ This digital data is collected by these internet AIs which in turn use the data to influence the users’ experience and purchasing habits.⁸⁰ Companies like Amazon are using this type of personal data to anticipate user purchases, often by moving items around the country to ensure popular items remain available in order to cut down on shipment times. Amazon plans to ensure the inventory in area-specific fulfillment centers matches the customer information, ranging from previous orders, unpurchased contents in an online shopping cart, online wish-lists, and even popular products for a region.⁸¹ The result of such predictive analysis translates into a smoother customer purchasing experience with a pleasant reward of receiving items quicker.

For the military, Amazon’s predictive analysis is a valued benchmark too. As more sensors are connected to military equipment and personnel, the revelation of what a unit’s exact usage of supplies, such as ammunition, fuel, water, and chow will be better substantiated and supported. The predictive analysis coming from these sensors installed on ground equipment will help to predict supply requirements and then help the combat services support units to

preposition additional supplies when and where our forces need them without creating lucrative logistical targets for the enemy. Additionally, ground equipment will need something like ALIS that can “predict component failures, decrease the frequency of unscheduled maintenance, and improve the productivity of repair operations.”⁸² Predictive analysis programs such as those found in ALIS will dramatically affect the ground supply and maintenance functions of combat services support units, through the use of leveraging predictive analysis of real-time data. The result is that commanders are informed of the real-time readiness and maintenance expectations of their unit. Ultimately, this advancement will save time, money, and lives from being lost on the battlefield.

Teaching Machines to Learn

Amazon’s desire to improve the customer’s experience through predictive analysis demonstrates another growing field within AI called machine learning (ML). The business dictionary defines ML as the “ability of a machine to improve its own performance through the use of software that employs AI techniques to mimic the ways by which humans seem to learn, such as repetition and experience.”⁸³ Put another way, ML is a field of computer science that studies the development of self-learning algorithms to gain an understanding of trend recognition and predictions from the data provided.⁸⁴

Furthermore, in his book *Foundations of Machine Learning*, Mehryar Mohri, a leading computer scientist in the field of machine learning, explains that ML encompasses three types of learning: supervised, unsupervised, and reinforcement.⁸⁵ Supervised learning uses a statistical process that begins with a body of categorized data (i.e., colors, shapes, size) that is put through rules (or algorithms) intended to explain trends found in the data, as well as attempts to predict future results of similar data.⁸⁶ As the supervised learning machine continues to receive and

process data, a reoccurring feedback loop of training, testing, and altering the machines' parameters to reach the best outcomes is achieved.⁸⁷ An example of current applications of supervised learning being employed is the area of risk assessment in financial services by minimizing risk in a company's portfolio, or by enhancing fraud detection used by financial institutions to confirm or deny a customer's purchases.⁸⁸

Most notable of these applications of supervised learning is cybersecurity where ML is making a significant stride in improving security on the internet. Cybersecurity is becoming a significant challenge and costing millions of dollars each year due to cyber attacks. According to the US government, "malicious cyber activity costs the US economy between \$57 billion and \$109 billion in 2016."⁸⁹ Furthermore, according to Morgan and Stanley, the private industry is specifically estimating that "spending on cybersecurity products and services will more than double from \$56 billion in 2015 to \$128 billion in 2020."⁹⁰ Likewise, cyber attacks are not just costing companies billions of dollars to try and stop, but are also costing nation-states their sensitive military secrets.

The US military's new F-35 is the latest potential casualty in malicious cyber activity. According to the US Department of Justice, "a Chinese National plead guilty to conspiring to hack into the US defense department."⁹¹ The information stolen by the Chinese national is suspected of being the blueprints to the F-35 fighter aircraft.⁹² Breaches in cybersecurity like that of the F-35 have given US adversaries a chance to match new technologies still being developed or soon to be in production. In the case of the F-35, the former Under Secretary of Defense for Acquisition, Technology and Logistics, Frank Kendall, noted these breaches "gave away a substantial advantage" by "reduce[ing] the costs and lead time of our adversaries to doing their own designs."⁹³ This gain is evidenced by similarities between the J-31, a new Chinese stealth

fighter, and the US F-35.⁹⁴ If China did, in fact, use the stolen designs, it allowed China to leap a generation ahead in fighter technology without spending the billions of dollars that the United States did to develop and produce the F-35 fifth-generation technology.⁹⁵ That shortcut could mean parity in the skies, compromising US defense for years to come.

To compound the problem, cybersecurity companies thirst for systems that can weather the tsunami of malicious cyber attacks coming every second. Additionally, these cybersecurity companies are anemic to the fact that they lack skilled cybersecurity workers able to handle the workload.⁹⁶ This compounding problem makes ML more enticing to respond to threats and ease the burdens on a strapped workforce. Also, supervised ML would provide the US military a significant ability to protect their networks as well.

Unsupervised learning is another type of ML and occurs when an algorithm learns from raw unlabeled data allowing the machine to determine patterns in the data on its own.⁹⁷ This method of learning can reveal valuable insight into different connections found within a collection of raw data.⁹⁸ Unsupervised learning offers an ability to capture information hidden within large groups of data, making data-driven decisions for predictive models more insightful. A few current examples of unsupervised learning are seen in the Amazon customer predictive analysis example given earlier, as well as supermarket purchasing habits, and accident-prone vehicle areas found on roadways.⁹⁹

Reinforcement learning is given a reward function in order to maximize its outcomes through a continuous trial and error approach and improves its performance as it continually interacts with a declared environment.¹⁰⁰ Similar to how humans learn, reinforcement learning learns through trial and error, with each error helping to mark a particular course of action as less successful than others.¹⁰¹ A reinforcement learning example can be found in Google's DeepMind

program that was coded to learn how to play old Atari videogames. As the program starts to learn how to play the game, it is inept and awkward. Gradually it improves with self-training until it becomes a champion.¹⁰²

Additionally, ML differs from that of the traditional approach to AI, in that traditional AI programmers engage with different industry experts to learn how their decision-making works, and then translate that process into software instructions. For traditional AI, emulation of an industry's decision-making process is paramount, whereas machine learning relies on statistical methods to find a decision process that works as well, if not better.¹⁰³ Another benefit of ML is that it can be used even when it is difficult to code explicit rules to solve specific problems.¹⁰⁴ There is little limit to the kinds of data ML can process. With ML, data can come in the form of digital information, satellite imagery, visual information, text, audio data, or unstructured data. The ability of a smartphone to learn and understand the user's exact way of speaking is an example of AI using ML technology.¹⁰⁵

There are a few recent examples of ML being used or sought after by the US military. Project Maven was a joint venture between the DoD and Google using ML to filter through video footage, provided by drones, to identify targets and persons of interest. The Pentagon wants to use AI to predict the next wildfire or natural disaster based off of historical data along with real-world data. Similarly, Special Operations Command (SOCOM) wants to use predictive analysis on SOCOM aircraft in order to predict maintenance requirements. Lastly, the intelligence community seeks to use ML to speed up the decision process requiring actions on targets.¹⁰⁶

The rise of the Autonomous Machines

As advancements in AI continue to replace humans by providing more efficiencies, speed, and accuracy in manual, repetitive, laborious, data-centric tasks, the problem of autonomy will arise. The Joint Concept for Robotic and Autonomous Systems (JCRAS) defines autonomy as, “The level of independence that humans grant a system to execute a given task. It is the condition or quality of being self-governing to achieve an assigned task based on the system’s situational awareness (integrated sensing, perceiving, analyzing), planning, and decision-making.”¹⁰⁷ With autonomous technology, routine human tasks are completed with limited outside control.¹⁰⁸ With a significant rise of interest in autonomous technology, the commercial industry is benefitting by having warehouses operate nearly autonomously.¹⁰⁹ Companies like Miller-Coors, Amazon, Wal-Mart, and many grocery store chains are using autonomous technology within their warehouses to improve efficiency, speed up production, limit loss, and respond faster to demands.¹¹⁰ For companies like Amazon, autonomous technology has allowed them to stay ahead of the increasing demands coming from their customers.

Moreover, this technology is never more relevant than it is with the numerous advancements in autonomous technology. For example, in new automobiles, a range of innovative autonomous features such as automatic braking, adaptive cruise control, automatic lane assists, and self-parking are making automobiles safer to drive.¹¹¹ These safety mechanisms are increasing in demand as the number of miles Americans drive increases each year. According to a National Highway Traffic Safety Administration (NHTSA) report, Americans drove over 3,213 billion miles in 2017.¹¹² However, of those billions of miles driven, the tragic reality that 37,133 people lost their lives in motor vehicle accidents.¹¹³ NHTSA's data shows that a high percentage of serious crashes are due to human error. Autonomous vehicles have the potential to

remove human error from the accident equation altogether. Moreover, autonomous vehicles are not a thing of *The Jetsons* cartoon anymore. Companies like Tesla and Google are taking significant strides in making these vehicles a reality today.¹¹⁴

Autonomy is providing a glimpse of what the removal of human interruption in a system can do in making a system run safer and smoother. Autonomous technologies are also being seen in both civilian and military aircraft, with systems like autopilot in commercial airliners or automatic ground collision avoidance system (Auto-GCAS) found in fighter jets.¹¹⁵

For the military, the benefits of autonomous technologies are not something totally new. The military has been pursuing autonomous technology for use since the American Civil war with the advent of the semi-autonomous Gatling gun.¹¹⁶ The Gatling gun was designed to provide one man the ability to produce the same amount of firepower as that of a hundred men.¹¹⁷ A few hundred years later and one finds the US Navy's semi-autonomous "Aegis combat system (ACS)."¹¹⁸ The ACS is an advanced command and control and weapon control system that uses integrated computers and radars to track and guide shipboard weapons systems to destroy enemy targets.¹¹⁹ The weapon system includes the MK41 vertical launching system, the Phalanx close-in weapon system, anti-submarine warfare systems, and Tomahawk land attack cruise missiles. The ACS is designed to fire with limited to no human interaction if so required.¹²⁰ Moreover, ACSs semi-autonomous function can process and take action on targets in a saturated threat environment faster and more effectively than humans.¹²¹

In addition to the Aegis system, the US Navy and Air Force have partnered on a project called the Long-Range Anti-Ship Missile (LRASM) system, which according to Lockheed Martin, has advanced sensors that provide the missile the ability to sense and avoid threats while

traveling to its target autonomously.¹²² The LRASM, along with the Aegis system, are just a few autonomous weapon systems the DoD currently possesses.

Likewise, autonomous systems are being further pursued by the DoD's many AI initiatives working in the area of robotics and autonomous systems (RAS). According to the DoD, RAS "offers a wide range of AI programs—not just weapon systems—that can complete 'dull, dangerous, and dirty' tasks— potentially reducing the risks to soldiers and Marines and possibly resulting in a generation of less expensive ground systems."¹²³ The US 2018 National Defense Strategy directs the Joint Force to, "invest broadly in military application of autonomy, artificial intelligence, and machine learning, including the rapid application of commercial breakthroughs, to gain competitive military advantages."¹²⁴ AI advances in RAS within the private sector in areas such as transportation, logistics, manufacturing, health care, and engineering could be eagerly altered to meet military needs.¹²⁵

Conversely, autonomous vehicle technology was initially developed between 2004 and 2007 through a Defense Advanced Research Projects Agency (DARPA) initiative.¹²⁶ The results of this program were encouraging, although the technology was not yet mature enough for widespread acceptance by both the military and private industry. A decade later, the private industry is on the edge of commercializing autonomous vehicles around the world, with companies like Tesla, as mentioned before, already offering an "autopilot" function in their cars.¹²⁷ Meanwhile, although the roots of autonomous vehicle technology started with DARPA, there has been dismal progress by the military in accepting autonomous vehicle technology.¹²⁸ Autonomous vehicles alone hold significant promise and potential for much of the ground components such as logistics and combat arms. One such autonomous vehicle program showing progress is the Army's Leader-Follower Technology for Tactical Wheeled Vehicles (TWVs)

effort which consists of a suite of sensors installed on existing vehicles that provide the capability to “link[ing] up to three unmanned vehicles to a single manned vehicle during the conduct of logistics road convoy operations.”¹²⁹ This technology allows large convoys to be conducted with minimal drivers, thereby limiting deaths due to roadside bombs or ambush. Going even further with this technology is the vision that autonomous startup *Embark* has embraced, upon where they foresee a day when “drivers are more like tug boat pilots, waiting at highway exit ramps for self-driving trucks to arrive and driving them into ‘port’—in this case, a distribution center.”¹³⁰

The technology of having different systems driven by autonomy is here and will change the face of the military forever. The coupling of autonomy and advancements in AI will cause autonomous platforms to have explosive growth in the automotive industry, which in turn will illustrate military capabilities that have not been considered yet.

Artificial Intelligence comes with risks

In August of 1945, the scientists of the Manhattan Project finally saw the effects of their bomb creation on the Japanese cities of Hiroshima and Nagasaki. Their life’s work was captured in but four years and brought to light in a mushroom cloud of destructive power, the likes that humanity had never experienced before. Emotions of guilt replaced the eagerness and exuberance of being the first to split the atom; regret surfaced when the news and facts of the destruction made it back to the Los Alamos laboratories in New Mexico.¹³¹ One of these scientists, Edward Teller, stated, “The nuclear reckoning preoccupied the experts in ways they had not foreseen: the ‘questionable morality’ of dropping the bomb without warning ‘profoundly disturbed’ many, and their moral qualms deepened after a second bomb destroyed Nagasaki.”¹³² The use of the atomic bombs shook many of the scientists involved, with many of them dealing

with self-condemnation, extreme guilt, and in their later years expressing regret for ever creating such a terrible technology.¹³³ For many of the scientists, they never imagined what unleashing such a terrible weapon could do to humanity.

For many scientists, technologists, and inventors, AI technology falls into the same category as the atomic technology discovered during WWII. However, there is little argument that AI is a world-changing technology. It is expected to affect the whole world in monumental ways, changing how the global economy operates, as well as completely impacting both private and public industries. The fact remains, the competitive advantage provided by the coming intelligence explosion will speed the development of AI so rapidly that human intelligence will be dwarfed by super-intelligent machines able to think 10,000 times faster.¹³⁴ This speed of commercial advancement and pursuit of AI solutions to military problems should concern the US military. Though AI will solve many problems today, the second and third order of effects provided by AI solutions are not yet known. Similarly, the scientists who created the atomic bomb eagerly pursued this endeavor, only to regret their creation after the fact. A scientist in the field of AI should heed the warnings of the past.

This speed of AI infused solutions toward military problems could spark AI induced problems that were never intended. The allure of speed infusing AI solutions can give users an unquestioning trust in these programs, thinking the computer has no faults.¹³⁵ The 2010 flash crash of the US stock market which lasted only 20 minutes demonstrates how a malfunctioning algorithm interacted with a “complex environment at superhuman speeds can be a catastrophic consequence.”¹³⁶ According to Ben Rooney, with CNN Money.com, “The Dow Jones industrial average plunged nearly 1,000 points, briefly erasing \$1 trillion in market value, before regaining much of the lost ground to close lower. It was the largest one-day drop on record.”¹³⁷ This

running amuck AI autonomous stock trading program foreshadows the risks if militaries adapt autonomous weapons.¹³⁸

Taking the previous example one step further, what would happen if an autonomous weapon was to malfunction, similar to that of the faulty algorithm in the flash crash? Would a military conflict start and or escalate out of control? Given the speed of this event, it would make it nearly impossible for humans to figure out what went wrong and then rectify the problem fast enough to prevent war.¹³⁹ Also, the speed would bring an untold amount of damages inflicted by a machine, making it significantly tragic and unfortunate.

This scenario brings up another risk that has already started to be of concern by both military and civilian organizations: What is the legality and ethics of an autonomous machine allowed to kill humans?¹⁴⁰ Department of Defense Directive 3000.09, Autonomy in Weapon Systems, “establishes guidelines designed to minimize the probability and consequences of failures in autonomous and semi-autonomous weapon systems that could lead to unintended engagements.”¹⁴¹ Unfortunately, the Directive does not encompass all autonomous systems the DoD may employ, such as cyberweapons, ships, vehicles, and noncombat aircraft.

As autonomy becomes ubiquitous throughout the military, the DoD Directive will need to incorporate these additional assets in any decision made to address the concern of AI-induced military action to kill a target.

AI extrapolations and recommendations

The basics of AI covered in this study make clear the need for a more significant study in AI and its subfields. A crossroads of warfighting is at hand, and the best direction to go requires some bold and insightful thinking. The fundamentals presented in this study will help to make this next step possible. Though a realization of the vast depth of this subject must be appreciated,

each subfield of AI mentioned in this study could provide more in-depth study, as numerous sources already exist for each field, with more being added as the technology continues to advance rapidly, and rapidly advancing it is. AI is literally on the cusp of exploding into every aspect of life, with the US military is rapidly positioning itself to reap the benefits of it, or, if unprepared, be left wanting by its arrival. As suggested in this study, the benefits to the Joint Force are immense. The US military cannot afford to fail to fully commit to AI advancement within the Joint Force. For the US military to be successful in the next war, the Joint Force must focus its efforts, make the tough decisions, and pursue what they know will help the United States to win the next fight. This will only happen if the Joint Force takes a significant lead and shows our adversaries what is possible when a military fully integrates AI. The alternative is woefully unacceptable and would require more blood and treasure to catch up.

Artificial intelligence is here to stay. The intelligence explosion is coming, and in order to grasp this key idea one must remain conversant as to what AI means up to this point, and what it will mean in the future. Additionally, asking what is best about AI is critical. New technology does not always mean all things positive – the dire consequences and risks of advancements are too often pronounced as collateral damage toward progress. AI will undoubtedly face this test in the coming years. When that test comes, military realities will find themselves at the center of this discussion. AI will be seen as an equalizer in the minds of many military thinkers and doers, which in turn will shape how future wars will be conducted. This thinking will surpass ill-informed representations of robots and networks gone rogue, to perhaps allowing lesser nation states to influence geopolitics like never before. Similar to the Soviet Union launching Sputnik catching the US unaware, the US must pay close attention to this capability to better serve its efforts to lead the world into a future on a peaceful basis. To this end, understanding and

adopting AI as a means of military augmentation must be valued and sought after by the Joint Force as a whole, while seeking to understand how AI can serve private interests that work to mitigate acts of war. The Joint Force must put itself in the center of this discussion, and lead the way in this kind of thinking.

Endnotes

¹ Allan Wasser, “LBJ’s Space Race: What We Didn’t Know Then,” The Space Review, Space Settlement Institute, (June 2005): 1, accessed April 23, 2019, <http://www.space-settlement-institute.org/Articles/LBJSpaceRaceHistory.pdf>.

² *Ibid.*, 2.

³ *Ibid.*, 1.

⁴ John R. Allen, and Amir Husain, “The Next Space Race is Artificial Intelligence,” *Foreign Policy*, November 2017, <https://foreignpolicy.com/2017/11/03/the-next-space-race-is-artificial-intelligence-and-america-is-losing-to-china/>.

⁵ *Ibid.*

⁶ Barack Obama, “State of the Union Address,” video, 67:30, address to Congress and the nation on January 26, 2011, <https://web.archive.org/web/20110126162407/http://www.whitehouse.gov/photos-and-video/video/2011/01/26/2011-state-union-address-enhanced-version>.

⁷ James N. Mattis, *Summary of the 2018 National Defense of the United States of America: Sharpening the American Military’s Competitive Edge* (Arlington, VA: Office of the Secretary of Defense, 2018), 1, <https://www.defense.gov/Portals/1/Documents/pubs/2018-National-Defense-Strategy-Summary.pdf>.

⁸ Graham Webster et al., “China’s Plan to ‘Lead’ in AI: Purpose, Prospects, and Problems,” *New America Foundation*, August 2017, <https://www.newamerica.org/cybersecurity-initiative/blog/chinas-plan-lead-ai-purpose-prospects-and-problems/>.

⁹ Graham Webster, et al., “Full Translation: China’s ‘New Generation Artificial Intelligence Development Plan’ (2017),” *New America Foundation*, November 2018, <https://www.newamerica.org/cybersecurity-initiative/digichina/blog/full-translation-chinas-new-generation-artificial-intelligence-development-plan-2017/>.

¹⁰ *Ibid.*

¹¹ Headquarters US Marine Corps, *Marine Corps Operating Concept: How an Expeditionary Force Operates in the 21st Century*, September 2016, 16 and 23, <https://www.mccdc.marines.mil/Portals/172/Docs/MCCDC/young/MCCDC-YH/document/final/Marine%20Corps%20Operating%20Concept%20Sept%202016.pdf?ver=2016-09-28-083439-483>.

¹² *Ibid.*, 23

¹³ Dirk Helbing, Bruno S. Frey, Gerd Gigerenzer, et al, “Will Democracy Survive Big Data and Artificial Intelligence?” *Scientific American*, February 2017, <https://www.scientificamerican.com/article/will-democracy-survive-big-data-and-artificial-intelligence/>.

¹⁴ James Barrat, *Our Final Invention: Artificial Intelligence and the End of the Human Era*. First Edition ed. (New York: Thomas Dunne Books, 2013), 4.

¹⁵ Darrell M. West and John R. Allen, *How artificial intelligence is transforming the world*, (Washington, DC: Brookings Institution Press, April 2018), <https://www.brookings.edu/research/how-artificial-intelligence-is-transforming-the-world/>.

¹⁶ Barack Obama, “State of the Union Address,” video, 67:30, address to Congress and the nation on January 26, 2011, accessed January 18, 2019, <https://web.archive.org/web/20110126162407/http://www.whitehouse.gov/photos-and-video/video/2011/01/26/2011-state-union-address-enhanced-version>.

¹⁷ John R. Allen, and Amir Husain, “The Next Space Race is Artificial Intelligence,” *Foreign Policy*, November 2017, <https://foreignpolicy.com/2017/11/03/the-next-space-race-is-artificial-intelligence-and-america-is-losing-to-china/>.

¹⁸ Arthur Koestler, *The Ghost in the Machine* (London: Hutchinson, 1967). Also references Rene Decartes “dualism,” Finally, *Deus ex Machina*, “a god from the machine,” employed in Greek tragedy to signify god dictating the outcome of a play.

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- ¹⁹ US Department of Defense, *Summary of the 2018 Department of Defense Artificial Intelligence Strategy* (Washington, DC: Office of the Under Secretary of Defense for Personnel and Readiness, February 2018), 4, <https://media.defense.gov/2019/Feb/12/2002088963/-1/-1/1/SUMMARY-OF-DOD-AI-STRATEGY.PDF>.
- ²⁰ *Ibid.*, 5.
- ²¹ *Merriam-Webster Online*, s.v. “Intelligence,” accessed: March 27, 2019, <https://www.merriam-webster.com/dictionary/intelligence>.
- ²² *Merriam-Webster Online*, s.v. “Artificial Intelligence,” accessed: March 27, 2019, <https://www.merriam-webster.com/dictionary/artificial%20intelligence>.
- ²³ Keith Frankish, *The Cambridge Handbook of Artificial Intelligence*, ed. William M Ramsey (Cambridge, UK: Cambridge University Press, 2014), 318.
- ²⁴ Darrell M. West, *What is Artificial Intelligence?* (Brooking Institute Press, October 2018), <https://www.brookings.edu/research/what-is-artificial-intelligence/>.
- ²⁵ Andreas Kaplan, Michael Haenlein, “Siri, Siri in my Hand, Who's the Fairest in the Land? On the Interpretations, Illustrations and Implications of Artificial Intelligence,” *Business Horizons* 62, no. 1 (2018), 19, <https://www.sciencedirect.com/science/article/pii/S0007681318301393>.
- ²⁶ Amir Husain, *The Sentient Machine: The Coming Age of Artificial Intelligence* (New York: Schribner, 2017), 20.
- ²⁷ John McCarthy, Marvin Minsky, Nathan Rochester, Claude Shannon, “A Proposal for the Dartmouth Summer Research Project on Artificial Intelligence” (Dartmouth University, 1955), accessed January 17, 2019, <http://www-formal.stanford.edu/jmc/history/dartmouth/dartmouth.html>.
- ²⁸ Executive Office of the President National Science and Technology Council Committee on Technology, *Preparing for the Future of Artificial Intelligence* (October 2016), 6, https://obamawhitehouse.archives.gov/sites/default/files/whitehouse_files/microsites/ostp/NSTC/preparing_for_the_future_of_ai.pdf
- ²⁹ Georgios Petropoulos, “Machines that Learn to do, and do to Learn: What is Artificial Intelligence?,” *Bruegel* (blog), April 6, 2017, <http://bruegel.org/2017/04/machines-that-learn-to-do-and-do-to-learn-what-is-artificial-intelligence/>; David Poole, Alan Mackworth, Randy Goebel, *Computational Intelligence: A Logical Approach* (New York: Oxford University Press, 1998).
- ³⁰ *Business Dictionary Online*, s.v. “data,” accessed: January 15, 2019. <http://www.businessdictionary.com/definition/data.html>
- ³¹ *Business Dictionary Online*, s.v. “algorithm,” accessed: January 15, 2019. <http://www.businessdictionary.com/definition/algorithm.html>
- ³² Darrel M. West, John R. Allen, *How artificial intelligence is transforming the world*, (Brookings Institute Press, April 2018), <https://www.brookings.edu/research/how-artificial-intelligence-is-transforming-the-world/>.
- ³³ Scott Humr, “Artificial Intelligence: Perspectives on Risks and Rewards for AI Technology Adoption” (Master’s thesis, Marine Corps University, 2017), 5.
- ³⁴ US Department of Defense, *Summary of the 2018 Department of Defense Artificial Intelligence Strategy*, 6.
- ³⁵ Executive Office of the President National Science and Technology Council Committee on Technology, *Preparing for the Future of Artificial Intelligence* (Washington, DC: Office of the President of the United States, October 2016), 7.
- ³⁶ Ben Dickson, “What is Narrow, General and Super Artificial Intelligence,” *Techtalks*, May 2017, <https://bdtechtalks.com/2017/05/12/what-is-narrow-general-and-super-artificial-intelligence/>.
- ³⁷ Executive Office of the President National Science and Technology Council Committee on Technology, *Preparing for the Future of Artificial Intelligence* (Washington, DC: Office of the President of the United States, October 2016), 7.
- ³⁸ Future of Life, “Benefits & Risks of Artificial Intelligence,” (Future of Life Institute, 2016), <https://futureoflife.org/background/benefits-risks-of-artificial-intelligence/?cn-reloaded=1>.

-
- ³⁹Ben Dickson, “What is Narrow, General and Super Artificial Intelligence,” *Techtalks*, May 2017, <https://bdtechtalks.com/2017/05/12/what-is-narrow-general-and-super-artificial-intelligence/>.
- ⁴⁰Darrel M. West, John R. Allen, *How artificial intelligence is transforming the world*, (Brookings Institute Press, April 2018), <https://www.brookings.edu/research/how-artificial-intelligence-is-transforming-the-world/>.
- ⁴¹Executive Office of the President National Science and Technology Council Committee on Technology, *Preparing for the Future of Artificial Intelligence* (Washington, DC: Office of the President of the United States, October 2016), 7.
- ⁴²Ben Dickson, “What is Narrow, General and Super Artificial Intelligence,” *Techtalks*, May 2017, <https://bdtechtalks.com/2017/05/12/what-is-narrow-general-and-super-artificial-intelligence/>.
- ⁴³*Ibid.*
- ⁴⁴Nick Bostrom, *Superintelligence: Paths, Dangers, Strategies*, read by Napoleon Ryan, 2014, audiobook, 5:47.
- ⁴⁵*Ibid.*, 5:51.
- ⁴⁶Executive Office of the President National Science and Technology Council Committee on Technology, *Preparing for the Future of Artificial Intelligence* (Washington, DC: Office of the President of the United States, October 2016), 8.
- ⁴⁷Good, I. J. (1965), Franz L. Alt; Morris Rubinoff, eds., *Speculations Concerning the First Ultraintelligent Machine*, *Advances in Computers*, 6, Academic Press, pp. 31–88, accessed March 28, 2019, https://web.archive.org/web/20120501043117/http://www.stat.vt.edu/tech_reports/2005/GoodTechReport.pdf, 31-33.
- ⁴⁸*Ibid.*, 33.
- ⁴⁹Executive Office of the President National Science and Technology Council Committee on Technology, *Preparing for the Future of Artificial Intelligence* (Washington, DC: Office of the President of the United States, October 2016), 7.
- ⁵⁰*Ibid.*
- ⁵¹*Ibid.*
- ⁵²Antony Adshead, “Data set to grow 10-fold by 2020 as internet of things takes off,” *ComputerWeekly.com*, April 9, 2014, <https://www.computerweekly.com/news/2240217788/Data-set-to-grow-10-fold-by-2020-as-internet-of-things-takes-off>.
- ⁵³“Internet of Things (IoT) connected devices installed base worldwide from 2015 to 2025 (in billions),” *Statista.com*, accessed January 17, 2019, <https://www.statista.com/statistics/471264/iot-number-of-connected-devices-worldwide/>.
- ⁵⁴Michael Kanellos, “152,000 Smart Devices Every Minute In 2025: IDC Outlines the Future of Smart Things,” *Forbes*, March 3, 2016, <https://www.forbes.com/sites/michaelkanellos/2016/03/03/152000-smart-devices-every-minute-in-2025-idc-outlines-the-future-of-smart-things/#25f448d44b63>.
- ⁵⁵Ty Pendlebury, “Smart TV: what you need to know,” *CNET.com*, July 2011, <https://www.cnet.com/news/smart-tv-what-you-need-to-know/>.
- ⁵⁶Amir Husain, *The Sentient Machine: The Coming Age of Artificial Intelligence* (New York: Schribner, 2017), 53.
- ⁵⁷Chief Information Officer, DoD Policy Recommendations for The Internet of Things (IoT) (Washington, DC: Department of Defense, 2016), A-5, <https://dodcio.defense.gov/Portals/0/Documents/Announcement/DoD%20Policy%20Recommendations%20for%20Internet%20of%20Things%20-%20White%20Paper.pdf?ver=2017-01-26-152811-440>.
- ⁵⁸Amir Husain, *The Sentient Machine: The Coming Age of Artificial Intelligence* (New York: Schribner, 2017), 53-54.
- ⁵⁹*Ibid.*, 54.
- ⁶⁰*Ibid.*, 54.
- ⁶¹*Ibid.*, 54.
- ⁶²*Ibid.*, 55.
- ⁶³iRobot, Roomba Vacuum Robots, <https://store.irobot.com/default/robot-vacuum-roomba/>;

-
- DSLR Pro, Construction Survey Drones, <https://www.dslrpros.com/construction-survey-drones.html>;
Craig Guillot, "Creating a Smart Warehouse with the Internet of Things," *Insights*, June 2016, accessed January 19, 2019, <https://insights.samsung.com/2016/06/24/creating-a-smart-warehouse-with-the-internet-of-things/>.
- ⁶⁴ David Jensen, "F-35 Integrated Sensor Suite: Lethal Combination," *Aviationtoday.com*, October 1, 2005, <https://www.aviationtoday.com/2005/10/01/f-35-integrated-sensor-suite-lethal-combination/>.
- ⁶⁵ *Ibid.*
- ⁶⁶ Autonomic Logistics Information System (ALIS), Lockheed Martin, accessed March 1, 2019, <https://www.lockheedmartin.com/en-us/products/autonomic-logistics-information-system-alis.html>.
- ⁶⁷ Aviad Simon, "F-35 – Fighter Jet Maintenance in The Age of Data," *Harvard Business School*, November 2016, <https://rctom.hbs.org/submission/f-35-fighter-jet-maintenance-in-the-age-of-data/#>.
- ⁶⁸ Autonomic Logistics Information System (ALIS), Lockheed Martin, accessed March 1, 2019, <https://www.lockheedmartin.com/en-us/products/autonomic-logistics-information-system-alis.html>.
- ⁶⁹ Aviad Simon, "F-35 – Fighter Jet Maintenance in The Age of Data," *Harvard Business School*.
- ⁷⁰ Amir Husain, *The Sentient Machine: The Coming Age of Artificial Intelligence*. 56.
- ⁷¹ *Ibid.*
- ⁷² Meghan Brown, "Smart Farming - Automated and Connected Agriculture," *Engineering.com*, March 2018, accessed March 1, 2019, <https://www.engineering.com/DesignerEdge/DesignerEdgeArticles/ArticleID/16653/Smart-FarmingAutomated-and-Connected-Agriculture.aspx>.
- ⁷³ *Ibid.*
- ⁷⁴ Agras MG-1 UAV, *DJI*, <https://www.dji.com/mg-1>, accessed March 1, 2019.
- ⁷⁵ Amir Husain, *The Sentient Machine: The Coming Age of Artificial Intelligence*. 56.
- ⁷⁶ Paul Scharre, "Army of None: Autonomous Weapons and the Future of War," (New York: WW Norton, 2018), 11-25.
- ⁷⁷ Kai-Fu Lee. *AI Superpowers: China, Silicon Valley, and the New World Order* (Boston: Houghton Mifflin Harcourt, 2018), 107.
- ⁷⁸ *Ibid.*
- ⁷⁹ *Ibid.*
- ⁸⁰ *Ibid.*
- ⁸¹ Megan Ray Nichols, "Amazon Wants to Use Predictive Analytics to Offer Anticipatory Shipping," *SmartDataCollective.com*, January 2018, accessed March 2, 2019, <https://www.smartdatacollective.com/amazon-wants-predictive-analytics-offer-anticipatory-shipping/>.
- ⁸² Sean Kimmons, "Initial Prototypes for Next-Generation Combat Vehicle to Focus on Manned-Unmanned Teaming," *Army News Service*, March 26, 2018, https://www.army.mil/article/202614/initial_prototypes_for_next_gen_combat_vehicle_to_focus_on_manned_unmanned_taming.
- ⁸³ *Business Dictionary Online*, s.v. "Machine learning," accessed: March 02, 2019, <http://www.businessdictionary.com/definition/machine-learning.html>.
- ⁸⁴ William R. Gery, SeYoung Lee, and Jacob Ninas, "Information Warfare in an Information Age," *Joint Force Quarterly* 85, no. 2 (April 2017): 29.
- ⁸⁵ Mehryar Mohri, Afshin Rostamizadeh, and Ameet Talwalkar, *Foundations of Machine Learning*. Second ed. (Cambridge, MA: The MIT Press, 2018), 7-8.
- ⁸⁶ Executive Office of the President National Science and Technology Council Committee on Technology, *Preparing for the Future of Artificial Intelligence* (Washington, DC: Office of the President of the United States, October 2016), 8.
- ⁸⁷ *Ibid.*, 9.
- ⁸⁸ "Supervised and Unsupervised Learning in Machine Learning," YouTube video, September 11, 2018, 5:05, https://www.youtube.com/watch?v=kE5QZ8G_78c, accessed March 5, 2019.
- ⁸⁹ Executive Office of the President, "The Cost of Malicious Cyber Activity to the U.S. Economy," *The Council of Economic Advisers*, (Washington, DC: Office of the President of the United States, February

2018), 36. <https://www.whitehouse.gov/wp-content/uploads/2018/03/The-Cost-of-Malicious-Cyber-Activity-to-the-U.S.-Economy.pdf>.

⁹⁰ *Ibid.*, 45.

⁹¹ U.S. Attorney's Office, "Chinese National Pleads Guilty to Conspiring to Hack into U.S. Defense Contractors' Systems to Steal Sensitive Military Information," (Washington, DC: U.S. Department of Justice, March 23, 2016), <https://www.justice.gov/usao-cdca/pr/chinese-national-pleads-guilty-conspiring-hack-us-defense-contractors-systems-steal>.

⁹² Executive Office of the President, "The Cost of Malicious Cyber Activity to the U.S. Economy," 35.

⁹³ U.S. Attorney's Office, "Chinese National Pleads Guilty to Conspiring to Hack into U.S. Defense Contractors' Systems to Steal Sensitive Military Information."

⁹⁴ Weisgerber, M., "China's Copycat Jet Raises Questions About F-35," *DefenseOne.com*, September 2015, accessed March 26, 2019. <http://www.defenseone.com/threats/2015/09/more-questions-f-35-after-new-specschinas-copycat/121859/>.

⁹⁵ *Ibid.*

⁹⁶ Duncan Riley, "Lack of skilled workers threatens enterprise security" *SiliconAngle.com*, March 7, 2019, <https://siliconangle.com/2019/03/07/new-report-finds-enterprise-security-facing-critical-skilled-staff-shortage/>.

⁹⁷ Mehryar Mohri, Afshin Rostamizadeh, and Ameet Talwalkar, *Foundations of Machine Learning*. Second ed. (Cambridge, MA: The MIT Press, 2018), 169.

⁹⁸ Sebastian Raschka, *Python: Deeper Insights into Machine Learning*, (Birmingham, UK: Packt Publishing Ltd, 2016), 8.

⁹⁹ "Supervised and Unsupervised Learning in Machine Learning," YouTube video.

¹⁰⁰ Sebastian Raschka, *Python: Deeper Insights Into Machine Learning*, (Birmingham, UK: Packt Publishing Ltd, 2016), 8.

¹⁰¹ *Ibid.*

¹⁰² John Paul Mueller and Luca Massaron, *Machine Learning for Dummies* (Hoboken: John Wiley & Sons, Incorporated, 2016), Accessed March 7, 2019. ProQuest Ebook Central, 169.

¹⁰³ Executive Office of the President National Science and Technology Council Committee on Technology, Preparing for the Future of Artificial Intelligence (Washington, DC: Office of the President of the United States, October 2016), 8.

¹⁰⁴ *Ibid.*

¹⁰⁵ John Paul Mueller and Luca Massaron, *Machine Learning for Dummies*, (Hoboken: John Wiley & Sons, Incorporated, 2016), 9.

¹⁰⁶ Cortney Weinbaum and John N.T. Shanahan, "Intelligence in a Data-Driven Age," *Joint Force Quarterly* 90, no. 3 (December 2018): 6.

¹⁰⁷ Andrew Feickert, Lawrence Kapp, Jennifer K. Elsea, Laurie A. Harris, *U.S. Ground Forces Robotics and Autonomous Systems (RAS) and Artificial Intelligence (AI): Considerations for Congress*, CRS Report for Congress R45392 (Washington, DC: Congressional Research Service, November 20, 2018), 2, <https://crsreports.congress.gov/product/pdf/R/R45392>.

¹⁰⁸ *Merriam-Webster's Online*, s.v. "autonomous," accessed: January 31, 2019, <https://www.merriam-webster.com/dictionary/autonomous>.

¹⁰⁹ Robert Libetti, "Autonomous Robots in the Grocery Warehouse," *WSJ.com*, Video, Sept 20, 2016, 0:30, <https://on.wsj.com/2GbYd9B>.

¹¹⁰ "Autonomous Robots in the Grocery Warehouse," *WSJ.com*, Video, Sept 20, 2016, 2:10, <https://www.wsj.com/video/autonomous-robots-in-the-grocery-warehouse/52D0ECC8-C0F6-4E9A-B6CB-CD4AAD31E1D4.html>.

¹¹¹ Umit Ozguner, Tankut Acarman, and Keith Redmill, *Autonomous Ground Vehicles*, (Norwood: Artech House, 2011), accessed March 9, 2019, ProQuest Ebook Central, 1.

¹¹² National Highway Traffic Safety Administration, "2017 Fatal Motor Vehicle Crashes: Overview" (Washington, D.C., U.S. Department of Transportation, October 2018), <https://crashstats.nhtsa.dot.gov/Api/Public/ViewPublication/812603>.

-
- ¹¹³ *Ibid.*, 2.
- ¹¹⁴ Laura Fraade-Blonar, and Kalra Nidhi, *Autonomous Vehicles and Federal Safety Standards: An Exemption to the Rule?* (Santa Monica, CA: RAND, 2017), accessed January 15, 2019. <http://www.jstor.org/stable/resrep17636>
- ¹¹⁵ Paul Scharre, *Army of None: Autonomous Weapons and the Future of War*, 28.
- ¹¹⁶ *Ibid.*, 35.
- ¹¹⁷ *Ibid.*, 35-38.
- ¹¹⁸ *Ibid.*, 163.
- ¹¹⁹ Mike Pearn, "Seek and Destroy: The Aegis Combat System," *NavyTechnology.com*, November 12, 2008, <https://www.naval-technology.com/features/feature45460/>.
- ¹²⁰ Paul Scharre, *Army of None: Autonomous Weapons and the Future of War*, 163-164.
- ¹²¹ *Ibid.*, 164.
- ¹²² Long Range Anti-Ship Missile (LRASM), Lockheed's description, accessed March 9, 2019. <https://www.lockheedmartin.com/en-us/products/long-range-anti-ship-missile.html>; Paul Scharre, *Army of None: Autonomous Weapons and the Future of War*, 63.
- ¹²³ Andrew Feickert, Lawrence Kapp, Jennifer K. Elsea, Laurie A. Harris, *U.S. Ground Forces Robotics and Autonomous Systems (RAS) and Artificial Intelligence (AI): Considerations for Congress*, CRS Report for Congress R45392 (Washington, DC: Congressional Research Service, November 20, 2018), 2, <https://crsreports.congress.gov/product/pdf/R/R45392>.
- ¹²⁴ James N. Mattis, *Summary of the 2018 National Defense of the United States of America: Sharpening the American Military's Competitive Edge* (Arlington, VA: Office of the Secretary of Defense, 2018), 7, <https://www.defense.gov/Portals/1/Documents/pubs/2018-National-Defense-Strategy-Summary.pdf>.
- ¹²⁵ Andrew Feickert, Lawrence Kapp, Jennifer K. Elsea, Laurie A. Harris, *U.S. Ground Forces Robotics and Autonomous Systems (RAS) and Artificial Intelligence (AI): Considerations for Congress*, 6.
- ¹²⁶ "The DARPA Grand Challenge: Ten Years Later," DARPA, March 13, 2014. <https://www.darpa.mil/news-events/2014-03-13>, accessed March 9, 2019.
- ¹²⁷ Andrew Feickert, Lawrence Kapp, Jennifer K. Elsea, Laurie A. Harris, *U.S. Ground Forces Robotics and Autonomous Systems (RAS) and Artificial Intelligence (AI): Considerations for Congress*, 21.
- ¹²⁸ M.L. Cummings, *Artificial Intelligence and the Future of Warfare*, Chatham House, The Royal Institute of International Affairs, January 2017, 4,9-10.
- ¹²⁹ Andrew Feickert, Lawrence Kapp, Jennifer K. Elsea, Laurie A. Harris, *U.S. Ground Forces Robotics and Autonomous Systems (RAS) and Artificial Intelligence (AI): Considerations for Congress*, 23.
- ¹³⁰ Aarian Marshal, "What Does Tesla's Automated Truck Mean for Truckers?" *Wired.com*, November 17, 2017, <https://www.wired.com/story/what-does-teslas-truck-mean-for-truckers/>, accessed March 17, 2019.
- ¹³¹ Paul Ham, *Hiroshima, Nagasaki: The Real Story of the Atomic Bombings and Their Aftermath*. First U.S. ed. New York: Thomas Dunne Books, (St. Martin's Press, 2014), 462.
- ¹³² *Ibid.*
- ¹³³ *Ibid.*, 465-467.
- ¹³⁴ Max Tegmark, *Life 3.0: Being Human in the Age of Artificial Intelligence*. First ed. (New York: Alfred A. Knopf, 2017), 134 -160; Nick Bostrom, *Superintelligence: Paths, Dangers, Strategies*. First ed. (Oxford: Oxford University Press), 2014.
- ¹³⁵ Paul Scharre, *Army of None: Autonomous Weapons and the Future of War*, 149.
- ¹³⁶ *Ibid.*, 203-204.
- ¹³⁷ Ben Rooney, "Trading program sparked May 'flash crash'" *CNNMoney.com*, October 1, 2010. https://money.cnn.com/2010/10/01/markets/SEC_CFTC_flash_crash/index.htm, accessed: March 26, 2019.
- ¹³⁸ Paul Scharre, *Army of None: Autonomous Weapons and the Future of War*, 229.
- ¹³⁹ *Ibid.*

¹⁴⁰ Andrew Feickert, Lawrence Kapp, Jennifer K. Elsea, Laurie A. Harris, *U.S. Ground Forces Robotics and Autonomous Systems (RAS) and Artificial Intelligence (AI): Considerations for Congress*, 11, 29, 37, 41-42.

¹⁴¹ Under Secretary of Defense for Policy, Department of Defense Directive (DoDD) 3000.09, *Autonomy in Weapon Systems*, (Washington, DC: Department of Defense, November 21, 2012), 1.

Bibliography

- Allen, Greg and Taniel Chan. *Artificial Intelligence and National Security*: Center for a New American Security, 2017. <http://www.jstor.org/stable/resrep06315>.
- Barrat, James. *Our Final Invention: Artificial Intelligence and the End of the Human Era*. Read by Gary Dana. Audible Studios. 2014. Audiobook, 9 hrs. 16 mins.
- Bostrom, Nick. *Superintelligence: Paths, Dangers, Strategies*. Read by Napoleon Ryan. Audible Studios. 2014. Audiobook, 14 hrs. 17 mins.
- Carr, Nicholas. *The Glass cage: Where automation is taking us*. Random House, 2015.
- Department of Defense. *Department of Defense Directive 3000.09, Autonomy in Weapons Systems*. Washington, DC: Department of Defense, 2017. <http://www.esd.whs.mil/Portals/54/Documents/DD/issuances/dodd/300009p.pdf>.
- Department of Defense. *Summary of the 2018 Department of defense Artificial intelligence strategy Harnessing AI to Advance Our Security and Prosperity*. Washington, DC: Department of Defense, 2019. <https://media.defense.gov/2019/Feb/12/2002088963/-1/-1/1/SUMMARY-OF-DOD-AI-STRATEGY.PDF>
- Executive Office of the President National Science and Technology Council Committee on Technology. *Preparing for the Future of Artificial Intelligence*. October 2016. https://www.whitehouse.gov/sites/default/files/whitehouse_files/microsites/ostp/NSTC/preparing_for_the_future_of_ai.pdf.
- Frankish, Keith. *The Cambridge Handbook of Artificial Intelligence*. Edited by William M Ramsey. Cambridge, UK: Cambridge University Press, 2014.
- Feickert, Andrew, Lawrence Kapp, Jennifer K. Elsea, Laurie A. Harris, *U.S. Ground Forces Robotics and Autonomous Systems (RAS) and Artificial Intelligence (AI): Considerations for Congress*, CRS Report for Congress R45392. Washington, DC: Congressional Research Service, November 20, 2018. <https://crsreports.congress.gov/product/pdf/R/R45392>.
- Ham, Paul. *Hiroshima, Nagasaki: The Real Story of the Atomic Bombings and Their Aftermath*. First U.S. ed. New York: Thomas Dunne Books, St. Martin's Press, 2014.
- Headquarters U. S. Marine Corps. *Marine Corps Operating Concept: How an Expeditionary Force Operates in the 21st Century*. September 2016. <https://www.mccdc.marines.mil/Portals/172/Docs/MCCDC/young/MCCDC-YH/document/final/Marine%20Corps%20Operating%20Concept%20Sept%202016.pdf?ver=2016-09-28-083439-483>.
- Humr, Scott. "Artificial Intelligence: Perspectives on Risks and Rewards for AI Technology Adoption." Master's thesis, Marine Corps University, 2017.

- Husain, Amir. *The Sentient Machine: The Coming Age of Artificial Intelligence*. First Scribner hardcover ed. New York: Scribner, 2017.
- Kania, Elsa B. *Battlefield Singularity; Artificial Intelligence, Military Revolution, and China's Future Military Power*: Center for a New American Security, 2017a. <http://www.jstor.org/stable/resrep16985>.
- Kania, Elsa B. *China's Rise in Artificial Intelligence and Future Military Capabilities*: Center for a New American Security, 2017b. <http://www.jstor.org.lomc.idm.oclc.org/stable/resrep16985.6>.
- Kurzweil, Ray. *The Singularity is Near: When Humans Transcend Biology*. New York: Viking, 2005. <http://www.loc.gov/catdir/enhancements/fy0719/2004061231-b.html>.
- Lee, Kai-Fu. *AI Superpowers: China, Silicon Valley, and the New World Order*. Boston: Houghton Mifflin Harcourt, 2018.
- Mattis, James N. *Summary of the 2018 National Defense of the United States of America: Sharpening the American Military's Competitive Edge*. Arlington, VA: Office of the Secretary of Defense, 2018. <https://www.defense.gov/Portals/1/Documents/pubs/2018-National-Defense-Strategy-Summary.pdf>.
- Mohri, Mehryar, Afshin Rostamizadeh, and Ameet Talwalkar. *Foundations of Machine Learning*. Second ed. Cambridge, MA: The MIT Press, 2018.
- Mueller, John Paul and Luca Massaron. *Machine Learning for Dummies*. Hoboken: John Wiley & Sons, Incorporated, 2016. <http://ebookcentral.proquest.com/lib/usmcu-ebooks/detail.action?docID=4526803>.
- National Science and Technology Council Networking and Information Technology Research and Development Subcommittee. *The National Artificial Intelligence Research and Development Strategic Plan*. October 2016. https://www.whitehouse.gov/sites/default/files/whitehouse_files/microsites/ostp/NSTC/national_ai_rd_strategic_plan.pdf.
- Obama, Barrack. "State of the Union Address," The White House video, January 26, 2011. <https://web.archive.org/web/20110126162407/http://www.whitehouse.gov/photos-and-video/video/2011/01/26/2011-state-union-address-enhanced-version>.
- Özgüner, Ümit, Tankut Acarman, and Keith A. Redmill. *Autonomous Ground Vehicles*. Boston: Artech House, 2011.
- Petropoulos, Georgios. "Machines that Learn to do, and do to Learn: What is Artificial Intelligence?" Bruegel. <https://search-proquest-com.lomc.idm.oclc.org/docview/1888642452?accountid=14746>.
- Pierce, Terry. *Warfighting and Disruptive Technologies: Disguising Innovation*. London: Routledge, 2004. <http://ebookcentral.proquest.com/lib/usmcu-ebooks/detail.action?docID=199690>.

- Raschka, Sebastian. *Python Machine Learning: Unlock Deeper Insights into Machine Learning with this Vital Guide to Cutting-Edge Predictive Analytics*. Birmingham, UK: Packt Publishing Ltd., 2015.
- Scharre, Paul. *Army of None: Autonomous Weapons and the Future of War*. First ed. New York; London: W. W. Norton & Company, 2018.
- Shmueli, Galit and Otto R. Koppius. "Predictive Analytics in Information Systems Research." *MIS Quarterly* 35, no. 3 (2011): 553-572. doi:10.2307/23042796.
<http://www.jstor.org.lomc.idm.oclc.org/stable/23042796>.
- Singer, P. W. and August Cole. *Ghost Fleet: A Novel of the Next World War*. Boston: Houghton Mifflin Harcourt, 2015.
- Tegmark, Max. *Life 3.0: Being Human in the Age of Artificial Intelligence*. First ed. New York: Alfred A. Knopf, 2017.
- US Department of Defense, *Summary of the 2018 Department of Defense Artificial Intelligence Strategy*. Washington, DC: Office of the Under Secretary of Defense for Personnel and Readiness, February 2018.
- US Department of Defense. 2012. "Directive No 3000.09." dtic.mil. November 21.
<http://www.dtic.mil/whs/directives/corres/pdf/300009p.pdf>.