Artificial Intelligence and Machine Learning:

Examining US and Chinese Policy Mechanisms for Strategic Advantage in Emerging Technology

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Introduction

In his book The Second Machine Age, Eric Brynjolfsson, Director of the MIT Initiative on the Digital Economy, describes the challenges we have in understanding Moore's law of exponential growth. He recounts an old tale on the origins of chess, where the emperor of the Gupta empire was so impressed by this new game that he offered the inventor anything he wanted. The inventor suggested the emperor place a grain of rice on the first square of the chessboard and double each subsequent square. It was only in the second half of the board that the emperor realized his error. After 32 squares, the emperor had given 4 billion grains of rice, the equivalent of one large field. However, had the emperor been able to fulfill the request through all 64 squares on the chessboard, he would have owed 18 quintillion (2^{64-1}) grains of rice…more rice than has ever been produced in the history of the world and if piled together would be pile higher than Mount Everest.[1] It was the second half of the board that created unfathomable increases. We stand, from a technology perspective, on the 32^{nd} square.

Brynjolfsson describes the technology age over the last decade as the start of "second half technology," where exponential growth will result in staggering advances. It is the exponential acceleration of the components of AI, chip technology, storage capability, breakthroughs in neural networks that are poised, within their own Moore's law exponential growth, to provide unheard of advances in the fields of Artificial Intelligence and Machine Learning (AI/ML). This capability to add intelligence to any system is

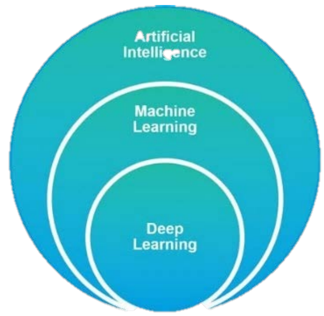
[1] Bryjolfsson and McAfee, *The Second Machine Age*, 46.

already revealing broad applications in the commercial world, and there are significant impacts to be felt in the National Security enterprise.

This paper examines the recent explosion of Artificial Intelligence and Machine Learning over the last five years and the policy efforts of the United States and China to understand and harness this technology to maintain global strategic advantage. It attempts to examine the policies of each nation holistically to provide recommendations on the way ahead for US investment and application of Artificial Intelligence and Machine learning to support the defense and intelligence efforts. This research begins under the premise that AI/ML represents a foundational general-purpose technology, similar to electricity or the combustion engine, with broad applications within the National Security enterprise and tremendous advantages for the country that creates applications through system cognification. This paper will first walk through the creation of relevant and applicable artificial intelligence and examples of its importance and significance to current National Security efforts. After examining recent AI/ML policies from the Chinese and US governments and how each government approaches and prioritizes AI/ML, recommendations to enhance US Strategic advantage will be provided to guide policymakers. The ultimate goal of this research is to highlight the critical role AI/ML will play in the next iteration of great power conflict and the importance of prioritizing the application of this technology for US strategic advantage.

The Future is Now

The Tipping Point of Machine Learning Research



Definitions and context matter when discussing Artificial Intelligence and Machine Learning. Often these terms become intertwined or used interchangeably when speaking to specific technologies. In this section, we will briefly outline the key terms and their relationships with one another, to provide a standard frame of reference for discussion.

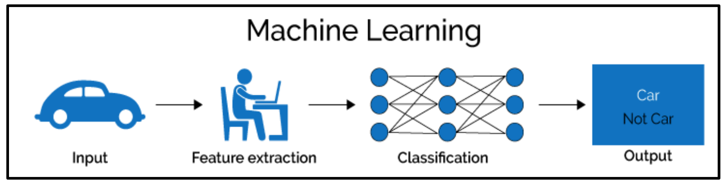
Artificial Intelligence (AI):

The European Commission's Expert Group on Artificial Intelligence had an elegant definition for this exploding field. "Artificial intelligence (AI) refers to systems that display intelligent behavior by analyzing their environment and taking actions – with some degree of autonomy – to achieve specific goals."[2] The systems referred to in this definition analyze their environment through data and discover patterns and relationships from that data. Science fiction and popular culture typically align AI with general-purpose intelligence, also known as artificial general intelligence, where super-intelligence systems have awareness and outperform humans in all areas. Most researchers agree that this level of cross-functional capability in AI is nowhere close realization, if at all. For the foreseeable future, this emerging technology is limited to AI

[2] EU Commission, "A Definition of Artificial Intelligence."

machines that are task-specific and narrow in their application. This narrow AI will still provide a tremendous advantage in domain-specific applications throughout society.

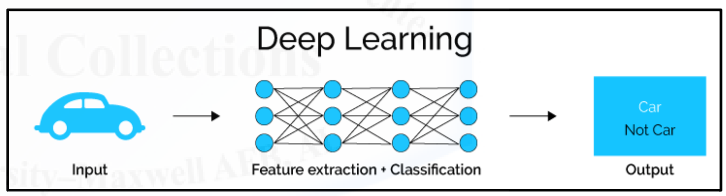
Machine Learning (ML):



(Gill, Xenonstack) 1

Machine Learning, a subset of Artificial Intelligence, derives complex algorithms from data. ML systems display basic cognition by learning to complete a task or function.[3] Machine learning leverages data to train itself on patterns and models to make future predictions on similar data sets.[4]

Deep Learning:



(Gill, Xenonstack) 2

Deep learning, a more complex iteration of machine learning, leverages layered neural networks to process large amounts of data and extract meaningful features at each layer. Features are lessons reflecting what was essential to achieve the desired output.[5] The output feature then functions as input at the next layer of the deep learning network. The critical distinction with deep learning and machine learning is that in deep learning no training data is given to the algorithm, and there are no rules programmed into the system. These elements are learned and reinforced in the layered network by exposure to large amounts of data. Deep learning,

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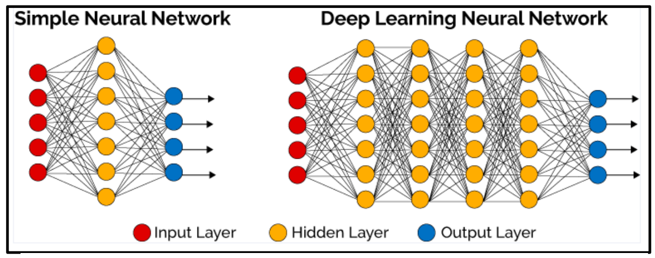
[3] Nilsson, "Council Post."
[4] Gupta and Bhatt, "Analysis of Different Domains of Artificial Intelligence."
[5] Foote, "A Brief History of Deep Learning."

in many ways, mimics the thought processes for learning within the mind.[6] Advances in chip technology have allowed significant deep learning breakthroughs in the areas of natural language processing and object detection.

Artificial Neural Networks (ANN):



(Gill, Xenonstack) 3

Neural Networks are the processing mechanisms within deep learning. ANN's can be both software and hardware as they model the neuron structure in a brain.[7] These multi-layer networks weigh variables, classify items, and make predictions based on data fed into the system.[8] An ANN takes an input (say a picture) and moves it through layers to interpret the picture (this is a picture of a dog). During the analysis of the picture, each layer weighs the connection between features and previous examples found in training data.[9] ANN's can adjust their algorithm to be more accurate based on the data it receives.[10] This methodology, called backpropagation, will be discussed later in this paper.

History of Machine Learning

The foundation for modern machine learning can be traced to early research in the 1940s and 1950s regarding theoretical assessments of neural activity and communication. Donald Hebb's book *The Organization of Behavior* examined the way

[6] Foote.
[7] "A Basic Introduction To Neural Networks."
[8] Yiu, "Understanding Neural Networks."
[9] EU Commission, "A Definition of Artificial Intelligence."
[10] Marr, "What Are Artificial Neural Networks - A Simple Explanation For Absolutely Anyone."

neural nodes "weighted" reactions to reinforce learning.[11] Hebb's work informed later research by Arthur Samuel to design a program that not only played checkers but remembered each position it had seen and the relative value of each move.[12] Samuel went on to coin the phrase Machine Learning in 1952. This back and forth between the biology and mechanics of neural activity continued to inform machine learning development.

In 1957, Frank Rosenblatt constructed the perceptron, the first software application for image recognition.[13] While the perceptron appeared to push the boundary of pattern recognition, it ultimately was lacking in some basic capability of object detection.[14] In 1969 Marvin Minsky released the book *Perceptrons*, where he argued that the perception approach was incompatible with multi-layered neural networks due to the computational requirements and number of programmed iterations needed.[15] The algorithm needed to train on a multi-layer system, known as backpropagation, would not be rediscovered until 1986. Also, the 1973 Lighthill Report from the British Science Research Council claimed researchers had overpromised and exaggerated capabilities within the field.[16] Funding and investment began to dry up, resulting in diminished efforts in the field. The next decade was marked by stagnation in machine learning research throughout the 1980s, and a schism developed within artificial intelligence research. On one side is the push to "expert systems" - logic-driven, knowledge-centric

[11] Foote, "A Brief History of Machine Learning."
[12] Marr, "A Short History of Machine Learning -- Every Manager Should Read."
[13] Foote, "A Brief History of Machine Learning."
[14] Foote.
[15] Jaspreet, "A Concise History of Neural Networks."
[16] Schuchmann, "History of the First AI Winter."

approaches to AI development that were domain-specific.[17] On the other side of the schism are the stalled fields of machine learning and neural network research.[18]

The rediscovery of backpropagation spawned the next surge for machine learning. In backpropagation, errors at the output of a system can be transmitted back through the layers of the network to train and reduce errors.[19] Also, boosting algorithms were developed in the 1990s to transfer weak learners within a system into strong learners by creating classifiers that increased their accuracy with data. The 2000s marked a moment when hardware began to reach processing speeds that allowed neural networks to compete with other systems. Graphic Processing Units (GPUs) would increase processing speeds by 1000 times over the next decade and allowed neural networks to achieve higher accuracy with data.[20]

The last decade has seen an explosion in deep learning capability. Driven mainly by advances in GPU chip technology, deep learning models are now tackling natural language processing and computer vision. The level of complexity achieved in just the last seven years is staggering. Consider AlexNet, a convoluted neural network that won the 2012 Imagenet challenge with a 15.3% error rate and sparked the Deep Learning revolution.[21] The Alexnet system was composed of only eight layers and a few million parameters, whereas newer neural networks can contain hundreds of layers and billions

[17] Dickson, "What Is the AI Winter?"
[18] Foote, "A Brief History of Machine Learning."
[19] Foote.
[20] Foote, "A Brief History of Deep Learning."
[21] Gao, "A Walk-through of AlexNet."

of parameters within the system.[22] Feeding this exponential growth is the seemingly limitless data explosion in the modern connected world.

Understanding the Development of A.I. through the Game of Go

Even a cursory examination of innovation over the last five years reveals a startling transformation in the technology landscape. The intersection of advancements in computing power, hardware development, software integration, low power chip technology, and the propagation of high-speed networks is propelling innovation at an unprecedented scale.

Noted technology executive and Chinese Venture Capitalist Kai-Fu Lee describes the watershed moments between March 2016 and May 2017 as China's "Sputnik moment," an event of national clarity that galvanized the attention of the government, industry, and population within China.[23] The game of Go, a complex strategy game originating out of China 2500 years ago, has deceptively simple rules but is incredibly complex in execution. Players alternate placing black and white stones at the intersections on a 19 by 19 grid. The goal is to capture territory on the board, and the player with the most territory wins. Go's complexity stems from the number of moves within a game and the number of iterations of games that are possible. To put it in perspective, after two moves in a chess game, a player has 400 possible moves available to them; in Go, there approximately 130,000 moves available.[24]

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22 "What's Fueling Deep Learning's 'Cambrian Explosion'?"
23 Lee, *AI Superpowers*, 3.
24 Muoio, "Why Go Is so Much Harder for A.I. to Beat than Chess."

"But as simple as the rules are, Go is a game of profound complexity. The search space in Go is vast -- more than a googol times larger than chess (***a number greater than there are atoms in the universe!***). As a result, traditional "brute force" A.I. methods -- which construct a search tree over all possible sequences of moves -- don't have a chance in Go."[25]

In March 2016, a South Korean Go champion, Lee Sedol, entered into a best of five competition against Google's Deepmind algorithm "AlphaGo." Lee Sedol was an 18-time International Champion and one of the best Go players in the world. AlphaGo won four out of the five games, only losing game four to Lee Sedol.[26] However, this would be the only time that AlphaGo would lose to a human competitor. How did Deepmind accomplish this feat in a game which, by their admission, was too complicated for a brute force algorithmic assessment of all possible moves? AlphaGo combined a standard decision tree with two distinct neural networks to more efficiently arrive at a move.

- **Policy Neural Network**: This deep neural network helps AlphaGo predict the next move and narrows the field of moves to consider to the ones most likely to lead to a win. By suggesting smart moves, the network narrows the multitude of options to the best ones.
- **Value Neural Network**: The value network essentially does an in-depth analysis of the best moves from the policy network and runs simulations to see which move is most likely to result in success. [27]

[25] Silver and Hassabis, "AlphaGo."
[26] "The Google DeepMind Challenge Match, March 2016."
[27] Silver and Hassabis, "AlphaGo."

Google researchers then trained AlphaGo off of 30 million moves from professional Go players and simulated millions of games…essentially giving AlphaGo the equivalent experience of playing Go continuously for 80 years![28] Here is where the potential applications of AI/ML bear significant fruit. The ability to simulate experience, and through that experience, reinforce learning and expertise at an astonishing pace, provides a natural segue to other applications. By leveraging simulation and experience, we can inform and drive decision making. While AlphaGo still offered a very narrow application in AI/ML, it showed modern algorithms coupled with neural networks, leveraging advanced chip technology, could tackle complex tasks and outperform humans.

This event took the academic and technology world by storm. It sent shockwaves through established circles as people grappled with the implications of this development. The engineers at Deepmind were not done, however, and continued to train their program for their next challenge, defeating a Chinese Go prodigy with a further refined version called AlphaGo Master.

On May 24th 2017, in an event hailed as the "Future of Go Summit," AlphaGo Master defeated 19-year-old Chinese Go master Ke Jie in three straight games. Unlike the competition against Lee Sedol, there seemed to be some consensus of another impending AlphaGo victory. The team had continued to run millions of simulated games to train the algorithm and had entered AlphaGo Master under a pseudonym into online games against professional Go players with a record 60-0.[29] The Chinese

[28] Muoio, "Why Go Is so Much Harder for A.I. to Beat than Chess."
[29] Metz, "AlphaGo's Designers Explore New AI After Winning Big in China."

government, fearing the matches would embarrass Chinese national prestige, chose to block the live streaming of the event.[30]

The genie, however, was out of the bottle, and the abstract notion of Artificial Intelligence and Machine Learning outperforming humans at complex tasks were irrevocably proven. Now a new set of questions would need to be answered. What nation would be at the leading edge of this technology? What are the ramifications for AI/ML employment across a wide array of technologies? If this AI/ML explosion is indeed akin to a general-purpose technology like electricity, what does it mean for industries affected by AI/ML employment? This first nation to understand the policy implications of AI/ML and establish a mechanism for using it would have a decisive advantage across all instruments of national power.

[30] Hern, "China Censored Google's AlphaGo Match against World's Best Go Player."

A Tale of Two Systems

"The military competitor who can harness and exploit AI's potential the fastest will accrue a significant military advantage. The Department must shape this emerging military-technical competition in AI to our advantage while ensuring a strong commitment to military ethics and AI safety." DOD Digital Modernization Strategy

Chinese Policy Approaches Towards Emerging Technology

Since China's epiphanic AlphaGo moment described in the introduction, the PRC has dedicated a whole of government approach to its efforts to lead the world in a myriad of emerging technologies, particularly in the areas of Artificial Intelligence and Machine Learning. It is telling that AlphaGo's victory over Lee Sedong went mostly unnoticed in the United States outside of some parts of the technology space, academic circles, and the Go community. However, it sent shockwaves through Asia, where Go players enjoy celebrity status. Over 200 million people watched or streamed the competition between AlphaGo and Lee Sedol.[31] By contrast, a month earlier, only 114.4 million people watched the Denver Broncos defeat the Carolina Panthers in Super Bowl 50.[32]

AlphaGo's victory begins a cascading effect in China, followed shortly after by the United States. Each nation begins to mobilize national resources and capability to establish competing innovation ecosystems to reach the forefront of research, development, and application in Artificial Intelligence using all elements of national power. The dominance of Deepmind against established Go masters galvanized Chinese efforts in the areas of Artificial Intelligence and Machine Learning. However, there was

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[31] "The Google DeepMind Challenge Match, March 2016."

[32] Pollatta and Stelter, "Super Bowl 50 Audience Is Third Largest in TV History."

already a concerted policy effort to align Chinese infrastructure, manufacturing, and economic effort with emerging technologies and high-value manufacturing. This effort allowed a quick focus of Chinese resources against the AI/ML problem set.

Made in China 2025

Released as official Chinese policy in 2015, "Made in China 2025" established clear goals to improve the Chinese industrial complex to compete on the global stage. Specifically, efforts under this policy sought to better position China in global production chains by increasing domestic production in key industries by 40% by 2020 and 70% by 2025.[33] China 2025 is unique in its shift to a "whole of manufacturing approach". This policy does emphasize emerging technology industries like advanced information technologies, automated robotics, and advanced materials, but also addresses quality manufacturing across industries.[34] The Chinese government's efforts within this policy place it clearly on track to compete globally in emerging technology spaces on both the R&D/innovation and value-added manufacturing fronts. China 2025 begins an industrial policy shift where a top-down, state-directed effort is underway to create not only internal innovation but a the re-innovation of foreign technologies.[35] While China 2025 predates the events in 2016 that ignited the AI boom, it had laid the foundation for China's innovation ecosystem.

[33] Kennedy, "Made in China 2025."
[34] Kennedy.
[35] Harrell, "China's Non-Traditional Espionage Against the United States."

China's 13th Five Year Plan

Beginning in 1953, the Chinese government has released a five-year plan (FYP) to outline strategic economic goals for the nation and align all levels of government toward these collective efforts. In March 2016, China's 13th five-year plan (2016-2020) created a blueprint for sustained growth and increased quality of life. A key element, which lays the foundation for subsequent policy on Artificial Intelligence, is the push for innovation-driven development.[36] The FYP reinforces three primary targets within the field of innovation, and the subsequent release if the 13th Five-Year Science and Technology Innovation Plan adds nine metrics to measure advancement in Chinese innovation. The three key targets were:

1) Raise R&D Spending: The 13th FYP sets a 2020 goal of raising R&D spending as a percentage of GDP from 2.1% in 2015 to 2.5% by 2020. The anticipated outcome of this increase is not just more funding for R&D, but also focused R&D that is market-based and built into a company's business model.[37]
2) Increase the Number and Quality of Patents: Chinese officials seek to raise patent submissions from 6.3 per 10,000 to 12 per 10,000 by 2020.[38] This strategic target seeks to grow Chinese patents within the country's innovation ecosystem, but also further refines the goal by seeking to raise the number of filed international patents through the Patent Cooperation Treaty.
3) Invest in Human Capital: The final strategic target is a continued increase in scientific degrees and R&D personnel per 10,000 employed persons. The goal

[36] Koleski, "China's 13th Five-Year Plan," 6.
[37] Koleski, 7.
[38] Koleski, 7.

is to increase the number of R&D personnel within the population from 48.5 per 10,000 in 2015 to 60 per 10,000 in 2020.[39]

China's New Generation Artificial Intelligence Development Plan

By July 2017, China has released its first policy-driven foray into Artificial Intelligence with the release of the "New Generation Artificial Intelligence Development Plan" (AIDP). This document, published by the Chinese State Council, outlines China's overarching goal of leveraging industrial and technological capabilities to propel China to the forefront of Artificial Intelligence research and application.

> "The rapid development of artificial intelligence will profoundly change human social life and the world. To seize the major strategic opportunities for the development of artificial intelligence, build China's first-mover advantage in artificial intelligence development, accelerate the construction of innovative countries and the world's science and technology power, this plan is enacted per the requirements of the CPC Central Committee and State Council."[40]

The AIDP established strategic benchmarks for China's development of Artificial Intelligence capability. The first benchmark, set for 2020, establish China as a peer competitor with other advanced Nations in the realm of AI. This stage focuses on the theory and technology of AI, industrial competitiveness through standardization, and by laying the groundwork for an AI innovation ecosystem.[41]

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[39] Koleski, 8.
[40] "China's New Generation of Artificial Intelligence Development Plan," 1.
[41] "China's New Generation of Artificial Intelligence Development Plan," 5.

The second strategic objective is to accomplish, by 2025, a significant advancement in Artificial Intelligence basic theory and research. There will also be scaled application of Artificial Intelligence in manufacturing, medicine, urban development ("smart cities"), and national defense.[42]

By 2030, the third phase will establish China as the global center of innovation and application of Artificial Intelligence. China will look to expand competitiveness in multiple industries, buttressed by a robust system of cross-functional technological integration. Estimates within this report project AI-related industry valuation at 1 Trillion yuan (140.7 Billion USD) and subsequent related industry valuations at 10 Trillion yuan (1.47 Trillion USD).[43] The People Republic of China recognized, even in this early policy release, the next great industrial revolution was underway, and the nation at the forefront of these technologies would have a distinct advantage across all the instruments of national power. So begins a Chinese whole of government effort, through licit and illicit means, to gain strategic advantage over the United States in emerging technology R&D, application, and advanced manufacturing.

U.S. Policy Approaches Towards Emerging Technology

While Artificial Intelligence has been looming large in the collective National Security consciousness for the last several years, it has only resulted in substantive policy efforts since late 2016. The Obama administration made the first push for a national framework regarding the future of Artificial Intelligence in October 2016 with the release of two reports. These reports marked the first push to define wholistic

[42] "China's New Generation of Artificial Intelligence Development Plan," 5.
[43] "China's New Generation of Artificial Intelligence Development Plan," 6.

government efforts into AI/ML but were released just as the US presidential election was concluding. National politics and subsequent changes in administration diminished the impact and reach of the reports.

Preparing for the Future of Artificial Intelligence

This document, prepared by the National Science and Technology Council (NSTC), identifies policy focus areas related to the employment of Artificial Intelligence. First, the report details the ways this technology can be leveraged for social good and to improve how the government operates.[44] There are recommendations to develop regulations that spur innovation while continuing to protect the public from misuse of this technology and ensuring public safety during early application.[45] It also explores the ramifications of autonomy on the workforce and economy. The NSTC document outlines key recommendations for establishing AI initiatives and communities of practice, leveraging AI in specific agencies, prioritizing open data and standardized data to feed AI initiatives, and how to engage international partners on AI standards for research and development.[46]

National Artificial Intelligence Research and Development Plan

The NSTC also released a more narrowly focused document examining the government's strategy for research and development in emerging technology. Specifically, the plan seeks to establish R&D emphasis in AI/ML and sets objectives for federally funded research within the government and in academia.[47] The R&D plan

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[44] "The Administration's Report on the Future of Artificial Intelligence."
[45] NSTC, "Preparing for the Future of AI," 1.
[46] NSTC, 42.
[47] NSTC, "The National Artificial Intelligence Research and Development Strategic Plan," 3.

identifies seven strategies for appropriate prioritization of AI research. It highlights the need for a long-term investment strategy to keep America at the leading edge of AI technology and reinforces the need for AI-human collaboration to optimize the advantages of this technology.

Evidence of the efficacy of human-AI interface arrived as early as 2016 in the medical field. An MIT paper on utilizing deep learning for the identification of metastatic breast cancer found that when given images of lymph node cells, an AI algorithm correctly identified cancerous masses 92.5% of the time, slightly lower than a standard pathologist detection rate of 96.5%. A combined approach yields a 99.5% successful detection rate for cancerous masses, an 85% reduction in error rate. [48] The study noted that integrating deep learning approaches into a workflow of medical diagnostics drives improvements in reproducibility, accuracy, and clinical value. [49]

The plan also addresses the need for ethical, legal, safety, and security concerns as systems adopt AI technology.[50] Measuring the progress of AI employment will require established standardization and benchmarks. The plan emphasizes the need for the government to make datasets available for training and testing of AI along with an active community of AI workforce to meet the growing demands of this new technology. Finally, it recommends establishing a framework to identify opportunities and coordinate investment in AI technology and further study to build a sustainable workforce for AI.[51]

[48] "Preparing for the Future of AI."
[49] Wang et al., "Deep Learning for Identifying Metastatic Breast Cancer."
[50] NSTC, 3.
[51] NSTC, 4.

2017 National Security Strategy (NSS)

By 2017, the national security apparatus had taken note of the importance of these emerging technologies as something beyond standard incremental technology improvements. Artificial Intelligence and Machine Learning represented general-purpose technologies that would have implications far beyond the narrow commercial applications currently in use. The NSS recognized not only the significant opportunities these technologies represent but the accompanying security challenges from near pear competitors.

> "Risks to U.S. national security will grow as competitors integrate information derived from personal and commercial sources with intelligence collection and data analytic capabilities based on Artificial Intelligence (AI) and machine learning."[52]

The NSS reinforces the need for the US to lead in research, technology, invention, and innovation. The importance of competitive and strategic advantage requires the US to identify emerging technology that is critical to economic growth and security and specifically highlights data science, autonomous technology, and artificial intelligence.[53] It prioritizes retention of US strategic advantage by understanding science and technology trends, attracting and retaining innovators through recruitment, and identifying ways to rapidly field innovation at the pace of the modern industry.[54] Through the security lens, the NSS identifies the dangers posed by competitors who leverage illicit acts to steal or gain access to advanced technology research within the US

[52] "2017 National Security Strategy of the United States of America," 34.
[53] "2017 National Security Strategy of the United States of America," 20.
[54] "2017 National Security Strategy of the United States of America," 21.

National Security Innovation Base (NSIB). The NSS highlights the growing trend of technology transfer through legal and illegal mechanisms that still have the net result of eroding US long term competitive advantage in emerging technology. It pushes for a greater understanding of these challenges, better protection of intellectual property, and enhanced protection of data and underlying infrastructure.[55]

2018 National Defense Strategy (NDS)

The NDS continues the National Security enterprise's push to define the security risks of emerging technology while harnessing its benefits for modern conflict. It also identifies a significant

> "The security environment is also affected by rapid technological advancements and the changing character of war. The drive to develop new technologies is relentless, expanding to more actors with lower barriers of entry, and moving at an accelerating speed." [56]

The NDS goes on to realize the duality of emerging technology. As AI advances rapid changes in our society through commercial applications, it also will change the nature of war and its execution. Historically, research in emerging technologies occurred within government-funded research, allowing greater control over access. The commercial genesis of today's advanced technology means state and non-state competitors will have access to these capabilities. If the Department of Defense is to maintain its technological advantage, it will need to shift industry culture, ways it invests, and

[55] "2017 National Security Strategy of the United States of America," 22.
[56] Mattis, "Summary of the 2018 National Defense Strategy," 3.

reinforce the protection of the National Security Innovation Base."[57] Failure to act will continue to erode our conventional advantage.

The NDS examines several capabilities for modernization of the force, and several of these are relevant to the Artificial Intelligence/Machine Learning arena. The strategy calls for broad investment in resilient, survivable, federated networks, and information ecosystems within the command and control, intelligence surveillance reconnaissance (C4ISR) mission space. In the area of autonomous systems, the NDS reinforces the NSS's emphasis on the rapid acquisition of autonomy, artificial intelligence, and machine learning advances in the commercial sector to gain military advantage.[58]

2019 DoD Artificial Intelligence Strategy

In early 2019 the Trump Administration issued an Executive Order on Maintaining American Leadership in Artificial Intelligence. It directed federal agencies to prioritize funding for Artificial Intelligence R&D while also charging agencies with identifying mechanisms to allow AI research using federal data.[59] A month later, the Department of Defense (DOD) released its strategy on Artificial Intelligence. It focuses on foundational tenets to accelerate and integrate AI development into the fabric of a modernizing force. Human-centric AI adoption is balanced with rapid iterative delivery of AI to allow scalable use across the Defense enterprise.[60] The plan identifies the need for a leading AI workforce and partnerships with academia, commercial tech, and international partners.[61]

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[57] Mattis, 3.
[58] Mattis, 6.
[59] Trump, "Executive Order on Maintaining American Leadership in Artificial Intelligence."
[60] "New Strategy Outlines Path Forward for Artificial Intelligence."
[61] "DOD AI Strategy," 7.

The Joint Artificial Intelligence Center is the established focal point for the DOD's work in AI/ML. By operating across the AI application life cycle. The JAIC provides consistency in approach and technology, particularly in near-term execution and adoption of AI.[62] Within the AI lifecycle, the JAIC will work to identify and deliver prototypes through National Mission Initiatives (NMI). These cross-functional teams will address operational challenges across the Joint force, merge research with operational needs, and scale successful prototypes across the enterprise.[63] The strategy recognizes that AI will change the character of conflict and the pace of threats in future crises. In turn, AI will internally impact all areas of Defense, from training and operations to acquisitions and healthcare.[64] The JAIC, using enterprise cloud technology, will address AI application and employment through a common foundation as a standardized mechanism for tools, data, and frameworks.[65]

In terms of partnerships, the DOD AI strategy leverages the Defense Advanced Research Projects Agency to enhance R&D collaborations with academic institutions, National Laboratories, and innovation centers around the US. The Defense Innovation Unit will continue to partner with private industry to adopt commercial capability through rapid prototype solutions.[66]

2019 DOD Digital Modernization Strategy (DDMS)

Several months after the DOD AI Strategy was released, the Defense department pushed its Digital Modernization Strategy. The AI Strategy assesses the ways the DOD will use

62 "DOD AI Strategy," 9.
63 "DOD AI Strategy," 9.
64 "New Strategy Outlines Path Forward for Artificial Intelligence."
65 "DOD Unveils Its Artificial Intelligence Strategy."
66 "DOD AI Strategy," 12.

AI and sets mechanisms for R&D, rapid prototyping, and employment. However, the Digital Modernization Strategy is the roadmap for the implementation of lines of effort through the lens of cloud, artificial intelligence, command, control and communications, and cybersecurity.[67] The DOD Chief Information Officer (CIO) describes the strategy as "the cornerstone for advancing our digital environment to afford the Joint Force a competitive advantage in the modern battlespace."[68] The DDMS has four pillars of modernization: cloud technology, artificial intelligence, command, control, and communications (C3), and cybersecurity. The cloud and AI pillars are connected in scope and execution, as a cloud enterprise will enable wide-spread information sharing across the Department and enhance efficiency and scaled data sharing to build AI/ML capability.[69]

The JAIC's common foundation will enhance AI scalability across all services. The JAIC will align with service mission requirements to deliver cloud and cognitive computing capability. By partnering with industry, The JAIC will accelerate the delivery of AI-enabled capabilities and address changes in warfighting and defense business operations. [70]

The DDMS recognizes a key modernization goal is to innovate for competitive advantage. In order to maintain and grow strategic advantage in a near pear or asymmetrical environment, the Department must have the ability to deliver technology

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[67] "DOD Digital Modernization Strategy 2019," 4.
[68] "DOD Digital Modernization Strategy 2019," 3.
[69] "Digital Modernization to Benefit Warfighters, DOD CIO Says."
[70] "DOD Digital Modernization Strategy 2019," 3.

more quickly and have an enterprise based on agility that allows us to maximize the advantages of innovative technology."[71]

2019 National Intelligence Strategy (NIS)

Artificial Intelligence and Machine Learning are specifically relevant to the Intelligence Community (IC). Advanced computational capabilities continue to provide economic benefits, but access to these technologies is uneven and increases division and instability in some parts of the world. The internet age was initially hailed as a boon for democracies around the world, allowing the free flow of information, ideas, and truth to permeate even the most oppressed, autocratic societies. However, recent events have shown that emerging technologies are often to surveil and oppress a population.[72] These issues position the IC to observe and focus policymakers on the global effects of emerging technology and to harness AI/ML for innovation within the analysis and reporting functions of their agencies.

The National Intelligence Strategy hopes to address these challenges by expanding the use of quantitative analytic methods for trend analysis in anticipatory intelligence operations. AI/ML will play an integral role in queueing agencies towards new assessments, changing conditions, and previously unknown linkages within vast data sets.[73] Innovation and information sharing are two enterprise objectives within the NIS designed to assist in the IC's effort to imbed emerging technology into the IC framework. The NIS directs the community to nurture innovative thought by developing and applying emerging technology. As data-driven technologies enhance the

[71] "DOD Digital Modernization Strategy 2019," 14.
[72] "2019 National Intelligence Strategy," 5.
[73] "2019 National Intelligence Strategy," 9.

IC's capabilities for analysis and execution, there also needs to be a concerted effort to harness the information environment to ensure organized, available, and usable data.[74] The NIS recognizes that these efforts will increase community insight and responsiveness by leveraging artificial intelligence, autonomy, and augmentation to the intelligence process.[75]

The policy initiatives laid out in this chapter highlight two very different approaches to solving the AI question. China's model is driven by a whole of government investment with a focus on dual-use technology and AI application at every echelon of government. This US model relies heavily on private industry as the technology leader and provides broad AI policy goals with decentralized execution. While the United States has a strategic advantage in AI research, there is serious concern over which model will create an advantage in the application of AI technology at the enterprise-level.

[74] "2019 National Intelligence Strategy," 22.
[75] "2019 National Intelligence Strategy," 21.

Strategic Advantage in AI/ML

"The National Defense Strategy makes clear that the character of warfare is changing. Our ultimate goal is to ensure our men and women in uniform maintain strategic advantage on the battlefield." Dana Deasy, DOD CIO

Near peer competitors like China view gaining global dominance in emerging technology as critical elements of economic development and national security efforts. [76] They have aligned internal manufacturing and external influence efforts to attain an advantage in a wide array of technologies. Many of their methods seek to disadvantage the United States through illicit means. It is worth noting that from 2011-2018 90% of the Department of Justice's economic espionage cases were aligned to China, and two-thirds of trade secret theft cases were China-centric. [77]

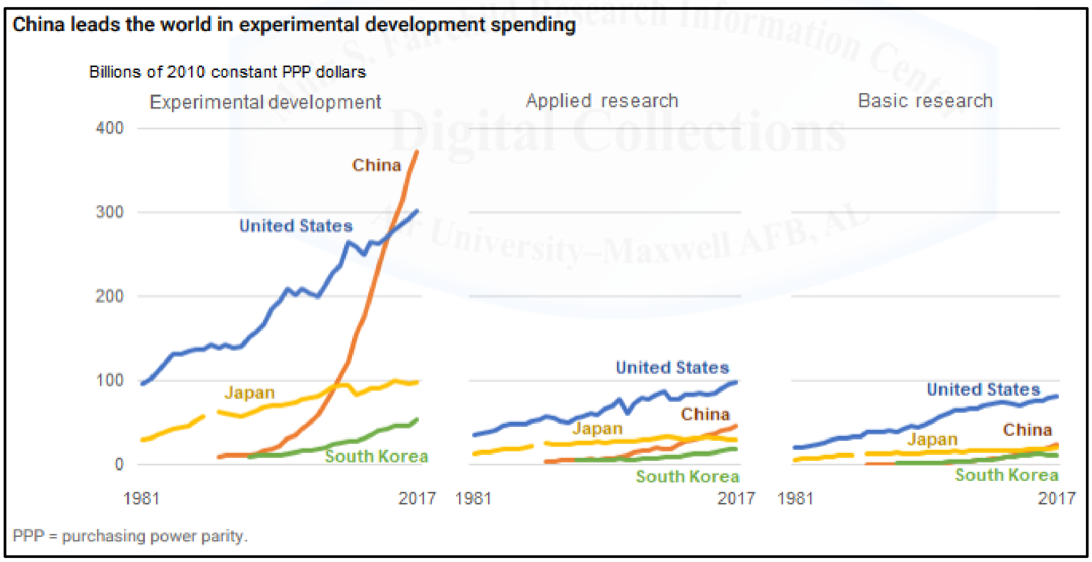
China has, for years, led a multi-faceted effort to achieve its national strategic goals regarding emerging technology and innovation.[78] Their non-traditional methods of collecting intellectual property have exploited loopholes and open access within the US innovation ecosystem. Chinese efforts have resulted in an alarming erosion of US strategic advantage as

(Demer DOJ Testimony) 4

[76] Harrell, "China's Non-Traditional Espionage Against the United States."
[77] Harrell, 5.

near-peer competitors leverage investments in startups, joint ventures, academia, and talent programs to gain access to sensitive information.

Commercial technology innovation, both in R&D and application, has outstripped government expenditures both in real dollars and as a percentage of gross domestic product, reinforcing the need for government and industry to partner directly on emerging technologies[79]. Even more alarming is the recent report by the National Science Foundation, highlighting the remarkable growth of Chinese investment in experimental development over the last decade. In 2017, China's investment in experimental development had grown over $370 billion, nearly $70 billion greater than the United States.[80]



(National Science Foundation) 5

As China continues to build and refine its innovation ecosystem, it seeks to siphon off intellectual property, proprietary information, and technology from the US innovation architecture. The US research enterprise has long attracted the world's best researchers.

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[79] National Science Foundation, "National Patterns of R&D Resources: 2017–18 Data."
[80] National Science Foundation, "China Leads the World in Experimental Development Spending."

It is built on the ideas of reciprocity, transparency, and merit-based competition. This openness has also made the US research enterprise vulnerable to exploitation by malign actors seeking to further their national interests. China has been at the forefront of these efforts.

Take the example of Micron, a US company based in Idaho that manufactured dynamic random-accessed memory (DRAM). The Chinese government identified DRAM as a national economic priority and began efforts to begin mass-producing it in China. Three Micron employees stole proprietary trade secrets and moved to a company in Taiwan that was in partnership with a Chinese state-owned company to manufacture these stolen chips.[81] When Micron sought legal redress, they were countersued by the Chinese entity for violation of Chinese patents based on the stolen intellectual property.

Often, China's efforts to achieve strategic advantage are attempted through direct investment or acquisition of sensitive technologies. These are no less dangerous than illicit means of IP acquisition and are often more challenging to create safeguards for US interests. Since the line is often blurred between commercial applications and military uses of emerging technology, the US must protect against foreign direct investment as a means of acquiring sensitive capabilities.

[81] Demer, China's Non-Traditional Espionage, 5.

Findings and Recommendations

"Artificial intelligence is one of the most profound things we are working on as humanity. It is more profound than fire or electricity." Sundar Pichai, Alphabet CEO

The explosion of Artificial Intelligence and Machine will change or disrupt most of the security mechanisms we have come to accept since WWII. The United States has enjoyed decades of significant strategic advantage born from our early adoption of technology to offset other nations' attempts to gain the upper hand. In the 1950s, our first offset came in the form of nuclear deterrence; in the 1970's investments in precision-guided munitions, stealth aircraft, and advanced intelligence, surveillance and reconnaissance platforms expanded our advantage in the second offset.[82] It is more than an evolution in technology, but a general-purpose technology with impacts beyond a standard upgrade in capability. AI/ML will create linkages between datasets that will inform decision-makers, send vital information to warfighters and disrupt what we think of as a "smart" weapon system. Artificial Intelligence will serve as the most significant strategic offset since the development of the nuclear bomb and will reshape society as profoundly as electricity. It is incumbent on decision-makers within the to push to be on the leading edge of not only the research and development but the application and employment of this technology. There are three key policy efforts where wholistic efforts will continue to drive US AI innovation National Security enterprise: human-AI Interface, freeing data, and funding strategic advantage.

[82] Keck, "A Tale of Two Offset Strategies."

Prioritizing Human-AI Interface:

Recommendation: *AI/ML applications within the National Security apparatus must prioritize human-AI interface to support technology uses that reinforce our values.*

While not directly addressed in this paper, the United States must be prepared to execute Artificial Intelligence in a manner consistent with our values and aligned with our beliefs. A key component to accomplishing this task will be investing in human-AI interface. Artificial intelligence will provide tipping and cueing pattern detection, and autonomy on an unprecedented scale. It cannot, however, make the final decisions on meaning, need, or action. In the Security and Defense domains, the "human in the loop," will remain a crucial component for the safe employment of this system. Research has already shown that AI and human intelligence have the best results against a problem when paired in a complementary fashion in the form of "augmented intelligence". [83]

Better detection rates through AI-human collaboration are directly applicable to intelligence, surveillance, and reconnaissance mission sets where advances in object detection and deep learning-enabled tipping and cueing of analysts could better respond to mission needs in real-time. This type of innovation is essential to provide strategic and tactical decision advantage for warfighters and policymakers. More research is needed on AI-human collaboration to create effective methods of interaction for application in defense and IC systems. [84]

[83] Dickson, "What Is the AI Winter?"
[84] "The National Artificial Intelligence R&D Plan."

Freeing Data across the National Security Enterprise

"The contest over information accelerates political, economic, and military competitions. Data, like energy, will shape U.S. economic prosperity and our future strategic position in the world. The ability to harness the power of data is fundamental to the continuing growth of America's economy, prevailing against hostile ideologies, and building and deploying the most effective military in the world."[85]

Recommendation: *The National Security enterprise needs to prioritize efforts to create a foundation for AI/ML applications that promotes interoperable data, and a cloud enterprise architecture to foster collaboration*

The most critical element to AI/ML employment is access to data that is visible, readable, trusted, and, most importantly, interoperable. There are a myriad of technical requirements to achieve this goal, from establishing mechanisms for uniformly storing data to incorporating IT solutions for metadata and source registry. Data within the National Security enterprise remains disjointed, unsearchable, and guarded in silos. This lapse is becoming a significant risk. Properly organized, formatted, and tagged data is essential to effective information-centric military and intelligence processes. [86]

Currently, the Department of Defense has no enterprise search function to enable the discovery of critical DoD data across its network security domains. [87] Additionally, there is no standard to store sensor data long term as most employment as at the tactical or operational point of need. Data storage standards must become an urgent priority for both the DOD and IC. Future system acquisitions need to come with a plan for the collection and storage of data that is interoperability and searchable throughout the enterprise. The defense and intelligence establishment can no longer afford to exist in

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[85] "2017 National Security Strategy of the United States of America," 3.
[86] "2019 National Intelligence Strategy," 22.
[87] "DOD Digital Modernization Strategy 2019," 17.

silos of excellence, where collaboration and data-sharing is the exception, but data access must become the norm. The National Security Strategy directly points to the need for incentivized information sharing not only to protect against and reduce vulnerabilities but also to improve network resilience. [88]

Recent initiatives like the Joint Enterprise Defense Infrastructure (JEDI) cloud and the MilCloud 2.0 are moving to provide fast, responsive, and scalable solutions for data.[89] Unfortunately, the $10 billion JEDI project is on hold as Amazon Web Services filed an objection to Microsoft's winning bid.[90] This objection threatens to delay the implementation of a cloud enterprise further. Unless the Department of Defense creates an application programming interface to ensure all cloud technologies can communicate on the federal level, we are moving towards silos of cloud technology that limit interoperability, posing a threat to AI/ML implementation across the defense and intelligence enterprise. The Federal government needs an established standard for security and interoperability. Agencies and services creating a stand-alone cloud should ensure their cloud enterprise can integrate into the larger network and facilitate the flow and access to clean data. Understandably, within the defense and intelligence enterprises, there will be varying degrees classification that will limit access. However, both communities need to recognize the importance of creating a common foundation for future action.

[88] "2017 National Security Strategy of the United States of America," 14.
[89] "DoD Enterprise Cloud."
[90] Rash, "Amazon Files Objection To DoD Motion To Revise Microsoft JEDI Decision."

Funding Strategic Advantage

Recommendation: *Investment in AI R&D, and more importantly, application at the operational level should be immediate, sustained, and represent at least 0.5% of the DOD Budget (~$3.5 billion).*

The United States far outstrips all other nations on expenditures for defense and security. However, Artificial Intelligence research, development, and application remain a small percentage of the overall budget. The President's FY2021 budget plan increases the National Science Foundation budget by 70% to $830 million for AI R&D and interdisciplinary research initiatives. Defense AI R&D budgets $459 million for DARPA efforts in AI, and the Joint AI Center budget jumped to $242 million. [91] The proposed FY 2021 budget for the DOD is $705.5 billion, making $841 million in total AI investment research, development, and application only 0.11% of the Defense budget.[92]

The National Security Enterprise must aggressively pursue application capability in artificial intelligence and machine learning. This means direct and sustained investment in AI/ML across the enterprise. Emphasis on direct investment reflects the National Security Commission on Artificial Intelligence's recommendation to double AI spending.[93] Also, the commission pushes for the DOD to accelerate AI application through top-down initiatives to overcome strategic barriers and institutional friction.[94] The commission recommends the formation of a Steering Committee on Emerging Technology chaired by leadership from the offices of the Director of National

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[91] Chawla, "US Govt Boosts Non-Defense R&D For AI and Quantum Computing."
[92] "DOD Releases Fiscal Year 2021 Budget Proposal."
[93] "NSCAI First Quarter Recommendations.Pdf," 2.
[94] "NSCAI First Quarter Recommendations.Pdf," 3.

Intelligence, Secretary of Defense, and Joint Chiefs of Staff to create organizational change drive defense investment. The goals and priorities of the US Artificial Intelligence strategy require foundational changes in acquisition strategy, personnel systems, medical data, workforce structure, data storage, and collection requiring significant investment across the National Security enterprise.

Closing Comments

Kai-Fu Lee, a Chinese venture capitalist and author of *AI Superpowers*, admits that the US still holds the advantage in AI research, where 68% of the top 1000 researchers are in the United States.[95] He correctly points out that China may hold an advantage in the application stage, where an army of AI engineers has the advantage in speed, execution, data access, and government support. The approach to AI/ML should be similar to industry's approach to electrification in the industrial revolution or the shift to the combustion engine. The major difference between those evolutions and the AI shift is the time horizon. The National Security Enterprise does not have a generation to plan and field this capability. Archaic acquisition and R&D processes will not suffice. Strategic advantage will be won in this arena through application. The US must prioritize rapid, iterative prototyping of AI/ML across the National Security enterprise through a network of readily available data, and with an emphasis on human-AI interface. Effective use of our innovation ecosystem can ensure the United States can maintain the strategic advantage in this critical emerging technology and protect the open system of research and development that allowed AI/ML to flourish.

[95] "Why China Can Do AI More Quickly and Effectively Than the US."

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