ARTIFICIAL INTELLIGENCE: A STRATEGIC DISRUPTOR IN AEROSPACE POWER EMPLOYMENT

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"By far the greatest danger of Artificial Intelligence is that people conclude too early that they understand it."

— Eliezer Yudkowsky

INTRODUCTION

Machine learning is when a computer system is not explicitly programmed to perform a task but learns during execution. Such systems learn by being fed a copious amount of training data that teaches them to do a certain task, like audio processing or feature identification in a video. The characteristics and amount of training data is critical to accurately undertake the designated task. Machine learning, however, is a subset of AI, which is a larger concept to create intelligent machines simulating human behaviour and thinking capability. AI researcher Francois Chollet said, "Intelligence is tied to a system's ability to adapt and improvise

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AI is a disruptive technology. The promises of AI are many, but their effectiveness in improving combat potential must be critically examined. This disruptive AI process will bring a paradigm shift and innovative military applications. Thus, it is important for military leaders to understand AI concepts fully and how to implement and deploy them to their advantage.

in a new environment, to generalise its knowledge and apply it to unfamiliar scenarios."[1]

The military leadership all across the world is now understanding the importance and potential value of exploiting AI. The question is whether leaders really understand the concepts of AI and can they lead in its military research and deployment? AI is a disruptive technology. The promises of AI are many, but their effectiveness in improving combat potential must be critically examined. This disruptive AI process will bring a paradigm shift and innovative military applications. Thus, it is important for military leaders to understand AI concepts fully and how to implement and deploy them to their advantage. A unified drive for AI may result in benefits but inadequately conceptualized AI applications can definitely result in catastrophic failures.[2]

REVISITING AI BASICS[3, 4]

Machine learning is largely based on neural networks that are mathematical models. These form a network of algorithms feeding data into each other. The weightage of the training data at each node of these neural networks is adjusted till it achieves the nearly desired output resulting in learning how to perform a particular task. These neural networks are further enlarged to bigger networks with increased algorithmic layers in Deep Learning networks and then trained

1. Nick Heath, "Topic: Managing AI and ML in the Enterprise", December 11, 2020, at https://www.zdnet.com/article/what-is-ai-everything-you-need-to-know-about-artificial-intelligence/. Accessed on February 17, 2021.
2. Stoney Trent and Scott Lathrop, A Primer on Artificial Intelligence for Military Leaders at https://smallwarsjournal.com/jrnl/art/primer-artificial-intelligence-military-leaders. Accessed on February 17, 2021.
3. Nick Heath, n. 1.
4. n. 2.

using large amounts of training data. These deep neural networks undertake tasks like speech recognition and computer vision.[5]

AI is used extensively for tasks associated with perception, which includes audio and image processing, reasoning used in problem solving, knowledge representation appropriate for modelling of systems, communication that uses language processing and autonomous systems in robotics engineering.

LEARNING PROCESS

The training of AI systems involves the use of many suitably labelled data sets that are annotated to highlight the features of interest. This process of teaching a machine by example is called supervised learning. The recent Generative Adversarial Networks (GANs) require few labelled datasets along with many unlabelled datasets for its training. This approach allows for a greater usage of semi-supervised learning, wherein less amount of labelled data is necessary for training systems than supervised learning.[6]

In contrast, algorithms in unsupervised learning aim to identify patterns in data that are used to categorise data. The algorithm is not pre-programmed to categorise data in any particular manner, but it attempts to look for similarities in data that can be grouped appropriately. In reinforcement learning, the algorithm recursively goes through a process of trial and error to reach the end state of the best possible outcome. Reinforcement learning is used to teach autonomous robots the optimal way to behave in real-world surroundings.[7]

Expert systems are programmed with decision rules to take decisions based on a large number of inputs, much like a human expert in a specific domain. Evolutionary computation, which is based on Darwin's theory of natural selection, is a relatively new branch of AI study. This computation allows the best result to evolve to a situation. Evolutionary computation is used to design AI algorithms for efficiently using AI to support construction of AI.[8]

5. Nick Heath, n. 1.
6. Ibid.
7. Ibid.
8. Ibid.

AI is used extensively for tasks associated with perception, which includes audio and image processing, reasoning used in problem solving, knowledge representation appropriate for modelling of systems, communication that uses language processing and autonomous systems in robotics engineering. AI systems require large amounts of data for its training and usage, but not the volume, velocity and variety related with "Big Data Analytics". Similarly, Big Data Analytics do not generally use artificial intelligence processes. The human reasoning and perceptions involved in the Observe-Orient-Decide-Act (OODA) decision cycle are modelled by the artificial intelligence simulations.[9]

AI APPROACHES

AI approaches are symbolic and non-symbolic. In the symbolic approach symbols are used to represent concepts, objects and relationships between objects. The reasoning work in the problem domain is used to develop ontologies and rules. The results of AI in this approach are readily explainable because they are based on the symbols which mankind understands. The input and information statement in AI that is not based on symbols is numerical, e.g. image pixels, audio frequencies, and only the output is sometimes converted to a symbol. Symbolic systems are based on considerable information gathering, whereas non-symbolic Machine Learning(ML) systems require large data gathering and analysis for correct categorisations, making them computationally intensive. AI research is targeted towards non-symbolic ML, and the most successful non-symbolic, supervised ML technique today is Deep Learning. At the implementation level AI systems may use a single, combination or hybrid approach with attendant compromises.[10]

INTERPRETABILITY & TRUST

Interpretability of the AI solution is an important aspect that must be addressed before the model's deployment in the field. The obscure mathematics and

9. n. 2.
10. Ibid.

huge data sets that support the applications makes it difficult in diagnosing output errors. The training data sets may also include sampling errors or intentional manipulation that become internalised in the AI system and may go unnoticed, which is an area of concern. Therefore specially skilled AI scientists are required to select and tailor the AI approaches. These people may not be fully aware of the combat perception necessary for successful employment. AI cannot handle unusual situations for which it has not been designed, and the results cannot be explained satisfactorily. As a result, the AI systems' trust will be doubted even when the solutions are optimal.[11]

The user must thoroughly know the function of planned systems and have a reliable feedback mechanism in place to determine when the system is working within established parameters and when it will depart from that role. DARPA is working to increase machine learning's ability to explain itself.

In a known automation performance envelop, trust is very important for the success of AI. The user must fully comprehend the role of designed systems and have a robust feedback mechanism to ascertain when the system is operating within the defined parameters and when it will deviate from its defined role. DARPA is undertaking research to improve the process of explaining and interpreting machine learning and deep learning models, in order to make it easier for the commander to comprehend why certain decisions have been made or predicted.[12] Therefore, it is a necessity that an interdisciplinary team of operations and AI experts collaborate within an AI program to interpret operational needs and technical possibilities.

MILITARY AI EMPLOYMENT

The AI employments are becoming more innovative, and cross implementation from one domain to another is becoming feasible. The benefits of AI-based picture recognition for airborne reconnaissance have been revealed by

11. Ibid.
12. Matt Turek, "Explainable Artificial Intelligence (XAI)", at https://www.darpa.mil/program/explainable-artificial-intelligence). Accessed on February 17, 2021.

Project Maven.[13] This will be used in weapon-control systems to reduce fratricide and enhance target identification.

Route and logistics planning tools can be enhanced with AI methods, to adjust shipping routes under uncertain combat situations. Similarly, war plan evaluations with probabilistic comparisons of complex courses of action are now distinctly possible. AI systems could improve long term capability acquisition decisions by fusing data about universal advancement in science and technology. The use of AI techniques in Information Operations has also been proven in the commercial sector.

Network planning, vulnerability identification and re-routing in cyberspace operations, has been validated in DARPA's Cyber Grand Challenge using expert AI approaches.[14] Deep neural networks can enhance communication systems by classifying interference and also optimising spectrum usage. AI will now be used for route planning, perception and tactical manoeuvre in combat autonomous vehicles.[15]

Any cyber-attack on the structure of a military AI deployment can have serious repercussions. The AI applications are typically designed to optimise multiple goals, and any attack which can introduce goal conflicts can erode the AI trust completely. Like in a logistics management system, maximum operational rate, minimum parts stockage and minimum risk to resupply missions are the goals that must be optimised. Any forced conflict within these parameters can change the outcome of supply-chain.[16] Similarly, targeting a single element of the Smart Warfighting Array of Reconfigurable Modules (SWARM) drones can disrupt the functioning of the entire entity. This is called the Butterfly Effect. This effect must be appreciated by the military commanders where small changes in a complex AI system can have dramatic effects over time.

13. Gregory Allen, "Project Maven brings AI to the fight against ISIS", *The Bulletin of the Atomic Scientists*, December 21, 2017, at https://thebulletin.org/project-maven-brings-ai-fight-against-isis11374. Accessed on February 17, 2021.
14. Matt Turek, n. 12.
15. n. 2.
16. Ibid.

DATA CRITICALITY IN AI

Management of data in AI is critical in all the areas of gathering, curation, storage and protection of sources. There must be very detailed and appropriate policies on its storage, regulations and laws that define access control. In most cases, AI applications will need senior leadership to accept responsibility and accountability for the integrity of training data as well as operational data. The training data and production system data must be compared, which is important for determining the fit of the AI system.[17]

It is a myth that AI will replace humans. AI applications allow for machine data interpretation, and free humans for the higher-level tasks.[18] While new technologies, like AI free humans from mundane and regular tasks, they also allow them to pursue higher goals. The human supervisory control systems will always be part of the command chain.[19]

China has publicised plans to become a world leader in AI.[20] Vladimir Putin has indicated that an AI leader will rule the world.[21] Australia has included AI literacy into their military training.[22] AI is now changing and creating new alignments in business and warfare. Military leaders must be now deeply aware of AI to invest in, and use these technologies wisely to ensure the security of the nation.

STATUS OF AI IN INDIA

AI deployments will change the military balance between nations, where conventional capabilities with and without AI will be relevant. The AI is a dual-use technology that will allow the middle powers to compete with their

17. Ibid.
18. Michael Horowitz, "The Promise and Peril of Military Applications of Artificial Intelligence", *The Bulletin of the Atomic Scientists*, April 23, 2018, at https://thebulletin.org/military-applications-artificial-intelligence/promise-and-peril-military-applications-artificial-intelligence. Accessed on February 17, 2021.
19. n. 2.
20. Paul Mozur, "Beijing Wants AI to Be Made in China by 2030", *New York Times*, July 20, 2017, at https://www.nytimes.com/2017/07/20/business/china-artificial-intelligence.html. Accessed on February 17, 2021.
21. Radina Gigova, "Who Vladimir Putin thinks will Rule the World", CNN, September 2, 2017, at https://www.cnn.com/2017/09/01/world/putin-artificial-intelligence-will-rule-world/index.html. Accessed on February 17, 2021.
22. n. 2.

National security decision makers have to be cautious and mainly focus on areas that are likely to succeed, leaving other areas as topics for research. It is very evident that not every security problem will be solved by AI.

superior adversaries and possibly induce an arms race in AI-dominated military capabilities. India must invest heavily in AI research and deployment of AI-enabled weapon systems. In January 2019, then Army Chief Gen. Bipin Rawat also stated that it is the right time now to introduce AI into the Indian military.[23]

What has India done so far?[24] In February 2019, an apex Defence AI Council (DAIC) headed by the Minister of Defence was established to provide strategic direction in the implementation of AI in defence. It will be a link between the government and industry and examine the suggestions for technology acquisitions and start-ups. Formation of a Defence AI Project Agency (DAIPA) as a central executive body is also being planned by DAIC.

The implementation of artificial intelligence in India is expounded in the Niti Aayog's 2018 paper, 'National Strategy for Artificial Intelligence #AIforAll.'[25] It makes no mention of AI employment and its challenges in the military sector. It is accepted that private sector will be crucial in the progress of AI to make it accessible and efficient. AI is capital intensive and requires highly-skilled technocrats. A vibrant public-private ecosystem is critical for supporting the free flow of capital and skills for technology innovation.

The MoD has now taken initiatives for capacity building within the defence, which includes knowledge creation by data collection and familiarizing the service personnel through training programmes. Each Service Headquarter (SHQ) is budgeted with Rs 100 crore for AI specific application developments. The Ministry of Defense recognises AI as a force multiplier and had directed

23. Ambuj Sahu, "Artificial Intelligence in Military Operations: Where does India Stand?" August 2, 2019, at https://www.orfonline.org/expert-speak/artificial-intelligence-military-operations-where-does-india-stand-54030/. Accessed on February 17, 2021.
24. Ibid.
25. Discussion Paper National Strategy for Artificial Intelligence at https://niti.gov.in/writereaddata/files/document_publication/NationalStrategy-for-AI-Discussion-Paper.pdf. Accessed on February 17, 2021.

the defence organisations to formulate their service-specific strategies for AI induction.[26]

The vision documents for research and development of AI of the world's leading powers, the US, China and the EU (and France), are in the public domain. India has no dearth of experts in Computer Science and Engineering in the institutes of national importance. A synergy between academia and industry is required to address the strategic and societal consequences of AI in defence, as well as to formulate a Vision document for the Indian military.

The 'Loyal Wingman' model has been developed by the USAF research laboratory. Here, a manned mother aircraft is paired with an unmanned aircraft assisting as a wingman.

AI IN AIR DOMAIN

A report titled "Air Dominance Through Machine Learning"[27] explains a proof-of-concept AI system that will allow new concepts of the air domain operations to be developed, and later evaluated. The model platform in this report has integrated open-source deep learning structures, current algorithms and the standard combat simulation tool of the US Department of Defense. It is looking at developing scalable and repeatable AI systems in the developmental arena of operational concepts. However, it is a collaborative learning of various AI agents in a very simple Suppression of Enemy Air Defence (SEAD) mission.

For applications involving strategic decision making, where simulations do not have physics to fall back on, there might be little correspondence between the real world and simulation. The trained algorithms of AI will be effectively useless. The end objective of high-level strategic reasoning is often

26. Implementation of Artificial Intelligence in Indian Defence Services, February 13, 2019, at https://elplaw.in/wp-content/uploads/2019/02/190213-Implementation-of-Artificial-Intelligence-in-Indian-Defence-Services.pdf. Accessed on February 17, 2021.
27. Li Ang Zhang, Jia Xu, Dara Gold, Jeff Hagen, Ajay K. Kochhar, Andrew J. Lohn, Osonde A. Osoba, "Air Dominance Through Machine Learning", at https://www.rand.org/content/dam/rand/pubs/research_reports/RR4300/RR4311/RAND_RR4311.pdf. Accessed on February 17, 2021.

to challenge or change the rules of the game rather than to optimise for best outcome within the constraints. Therefore, national security decision makers have to be cautious and mainly focus on areas that are likely to succeed, leaving other areas as topics for research. It is very evident that not every security problem will be solved by AI.

On December 15, 2020, US Air Force flew for the first time with embedded Artificial Intelligence algorithm called ARTUμ, as a working aircrew member aboard the U-2 Dragon Lady piloted by US Air Force Maj. "Vudu". The U-2 Federal Laboratory researchers have developed and trained ARTUμ to undertake what the pilot would do in a particular mission situation. The flight was intended to demonstrate the new technology, for which an exact scenario pitting the AI against another dynamic computer algorithm was constructed. The developmental team effectively used the open-source container-orchestration software Kubernetes to develop the application architecture.[28]

Dr. William Roper, assistant secretary in the Air Force for acquisition, technology and logistics said, "Putting AI safely in command of a U.S. military system for the first-time ushers in a new age of human-machine teaming and algorithmic competition. Failing to realize AI's full potential will mean ceding decision advantage to our adversaries." Secretary of the Air Force Barbara Barrett said, "Innovations in artificial intelligence will transform both the air and space domains."[29]

The 'Loyal Wingman' model has been developed by the USAF research laboratory. Here, a manned mother aircraft is paired with an unmanned aircraft assisting as a wingman. In 2015, an unmanned F-16 had been paired with a manned F-16 for a demonstration flight. In the enhanced 2017 flight, the pilotless F-16 broke away from the formation, attacked simulated targets on the ground, changed its flight in reaction to mock threats and other

28. "AI Copilot: Air Force Achieves First Military Flight with Artificial Intelligence", Secretary of the Air Force Public Affairs, December 16, 2020, at https://www.af.mil/News/Article-Display/Article/2448376/ai-copilot-air-force-achieves-first-military-flight-with-artificial-intelligence/. Accessed on February 21, 2021.
29. Ibid.

dynamic scenarios, and re-joined the manned aircraft.[30] USAF has plans now to undertake the same with the F-35 Joint Strike Fighter.

In the 2017 F-16 test scenario, the unmanned F-16 conducted a controlled flight profile only and no thinking AI based tasks were undertaken.[31] A more advanced AI requirement is called 'Flocking', which is different from the 'Loyal Wingman'. The commander controls a set number of unmanned aircraft in Flocking, but not the entire group for the purpose of executing the planned objective. In March 2018, the USAF Research Lab released an innovative video demonstrating the use of one F-35A employed with six stealth UCAVs. The XQ-58A 'Valkyrie' (formerly known as the XQ-222), is a multi-purpose unmanned aircraft that is being progressed in a LCAAT (Low Cost Attritable Aircraft Technology) program.[32]

'Swarming' is a step further in the idea of flocking. Here the commander does not know the status of individual members of the group. The mission is commanded to the entire group as a single entity.[33] The swarm members will execute the combat mission as a group. A swarm of 103 'Perdix' autonomous micro-drones were ejected from a fighter aircraft during in October 2016. The 290 gm Perdix are 16.5 cm long having a wingspan of 30 cm and can fly at maximum speed of 113 kmph for 20 minutes. The swarm successfully demonstrated group decision-making, adaptive flying, and self-healing abilities. These were not intended for any attack missions, but rather for reconnaissance and surveillance, detecting and tracking targets, or conducting electronic warfare measures. These swarms can be used as expendable decoys to spoof enemy air defences by feigning as larger targets.[34]

30. "This is What the US Air Force Wants You To Think Air Combat Will Look Like in 2030", *The Drive*, March 23, 2018, at http://www.thedrive.com/the-war-zone/19636/this-is-what-the-us-air-force-wants-you-to-think-air-combat-will-look-like-in-2030. Accessed on February 21, 2021.
31. n. 2.
32. "Loyal Wingman, Flocking, and Swarming: New Models of Distributed Airpower", *War on the Rocks*, February 21, 2018, at https://warontherocks.com/2018/02/loyal-wingman-flocking-swarming-new-models-distributed-airpower/. Accessed on February 21, 2021.
33. n. 2.
34. Kyle Mizikamo, "The Pentagon's Autonomous Swarming Drones Are the Most Unsettling Thing You'll See Today", *Popular Mechanics*, January 9, 2017, at https://www.popularmechanics.com/military/aviation/a24675/pentagon-autonomous-swarming-drones/. Accessed on February 21, 2021.

MITIGATION OF AI RISKS

AI technologies also have shortcomings and risks that must be assessed and mitigated. AI systems by their very nature are trained for specific tasks. In the fog of war, the combat environment is very dynamic and has uncertainties galore. This is an employment challenge for the combat forces and it becomes more concerning when the adversary will attempt to disrupt and deny the use of such systems. The AI outputs available to the commander or the weapon system may not be considered reliable, and hence the trust on the AI will erode. This inability of AI to adapt to the changing environment, particularly in air combat, will have to be addressed by the human in the loop with command overrides. In times of war, the militaries need to be assured of the reliability and trust it can repose in the AI systems. The issue, therefore, needs to be understood by the military commanders at static headquarters, battlefield command posts or the pilot in the war fighter. The operator must be aware of how AI will perform in a given scenario in order to pre-plan essential procedures that are frictionless and accident-free.[35]

It is not what AI can do in the future with deep learning algorithms, but about which capabilities commanders can trust these machines to do in combat that is important. As trust in these activities grows, these machines will be able to perform more local processing and hence be more autonomous in their task execution without supervision and digital data connectivity requirements from command centres. The need of suitable standards, certifications, quality assurances and accountability of the man-machine interfaces are crucial in AI development. Military leadership must provide the necessary impetus suitable for deploying AI in the combat environment.[36]

The developments of AI in civil domains must be closely observed by the military planners but more often than-not these cannot be directly applied into the military domains. The ethical and legal issues will assume significance

35. Michael C. Horowitz, n. 18.
36. UK Ministry of Defence, "Joint Concept Note 1/18 – Human-Machine Teaming", May 2018, at https://assets.publishing.service.gov.uk/government/uploads/system/uploads/attachment_data/file/709359/20180517-concepts_uk_human_machine_teaming_jcn_1_18.pdf. Accessed on February 21, 2021.

and the military commanders will need to adjust these technologies suitably for the combat environment. Military planners will have to address the dichotomy of rapid advances of civil AI and choose those technologies with greater care which are suitable in the military environment.[37]

AI and big data analytics are rapidly advancing and their applications are likely to have a considerable impact on military strategic and tactical decision making. How this pans out in future will entirely depend on the trust and acceptability of the military commanders on these AI machines, as well as maturing of the stated capabilities.[38]

AI IN AERONAUTICAL DATA

How to implement a predictive maintenance schedule using the AI reinforcement learning method is a challenge. The aircraft manufacturer has unique challenges of protecting military and also the commercial aircraft data. The flight data of thousands of flights over the life cycle of each aircraft need to be analysed to predict failures and suggest predictive maintenance schedules. A rough estimate indicates that more than 200,000 data points per flight per aircraft need analysis. Mining the core of this information is a difficult task of the data scientists.

The conventional approach in the aviation industry is to accumulate data via big data and analyse it in order to propose fleet management optimisation services. Dassault Aviation goes further with 3D Experience and the Big Data platform. The Digital Twin is an extension of the digital model, a product of the Dassault Aviation-Dassault Systèmes collaboration that has become a global standard. When in service, each aircraft behaves differently and requires specific maintenance operations according to the events of its operational life. A digital twin corresponds to a personalised and upgradeable digital model of a customer's aircraft, from design to manufacturing, maintenance

37. NATO STO, "Big Data and Artificial Intelligence for Decision Making: Dutch Position Paper", MP-IST-160-PP-1. May 25, 2018, p. 6. Accessed on February 21, 2021.
38. Andy J. Fawkes, "The Future Role of Artificial Intelligence Military Opportunities and Challenges", Consultant Thinke Company Ltd By Lieutenant Colonel Martin Menzel, DEU A, JAPCC, at https://www.japcc.org/the-future-role-of-artificial-intelligence/. Accessed on February 21, 2021.

The balancing of conventional forces by the use of nuclear weapons by US against the USSR has been described as 'offset' strategy. The 'second offset' strategy was the development of information technology in the 1970s, and now AI is published in the US as a 'third offset'.

and end of life. Dassault Aviation already uses a digital twin for the Rafale maintenance contract, called Ravel, signed in May 2019 with the Aviation Maintenance Division (DMAé) of the French Ministry of Armed Forces. The Big Data platform collects all the Rafale usage data from the "Fleet IS". It allows monitoring of Ravel contract performances, generation of lessons learned, and enrichment of predictive maintenance algorithms. The platform is dual. It can also securely process data from the Falcon fleets and generate what we call the individual "health records" of Falcon aircraft in service.[39]

In March 2018, the French Defense Procurement Agency DGA contracted Dassault Aviation and Thales to develop an innovation-producing ecosystem based on AI and applicable to military aviation: this preliminary study program is called Man Machine Teaming (MMT). The goal is to identify innovations, evaluate them, bring them to maturity, and eventually integrate them into the development of new fighter jets, namely the future Rafale standards and the new generation fighters. By the end of 2018, 19 projects had already started in MMT involving 16 companies, 8 start-ups and 4 labs across all of France. A second set of 19 projects was notified in November 2019. As part of the design of the Future Combat Air System (FCAS), the Man-Machine Teaming (MMT) project explores the feasibility of developing a cognitive air system. The principle of the cognitive air system is to offer a collaborative approach to allow greater AI autonomy and an optimised man-machine interface working harmoniously and efficiently in combat decision making.[40]

39. "Dassault Aviation and Artificial Intelligence", at https://www.dassault-aviation.com/en/group/about-us/artificial-intelligence/dassault-aviation-and-artificial-intelligence/. Accessed on February 21, 2021.
40. Ibid.

AI IN MILITARY INTERNET OF THINGS

TinyML is a technology of deep learning AI in which the machine learning algorithm has the capability to run on a microcontroller. TinyML is novel technology that has moved AI to end devices and opened up many possibilities. AI algorithms are resource intensive and are deployed in computational rich environment. TinyML models are now the most efficient and cost-effective way of imparting AI into IoT devices including military IoT.

When fully operationalised, the AI systems will certainly change the structure of the battlefield and flatten the military organisation. The impact of AI on society as a whole will be more intense than that of the nuclear revolution and will extend far beyond military issues.

Machine learning on small IoT devices presents several challenges to designers: power consumption, latency and accuracy. Many of us are familiar with the concept of machine learning as it pertains to neural networks. TinyML refers to the machine learning technologies on the tiniest of microprocessors using the least amount of power (usually in mW range and lower) while aiming for maximised results. The concept is to shrink the pre-trained large models into smaller ones without losing accuracy. This can be achieved in processes like pruning and deep compression. Pruning separates out synapses and neurons, resulting in ten times fewer connections. Deep compression takes pruning a step further with quantisation (fewer bits per weight) and a technique known as "Huffman Encoding."[41]

AI IN DISRUPTIVE WAR WAGING CHARACTER

The AI in military aerospace will forever change the nature of combat. Processing of large amount of data within the OODA cycle will be a paradigm

41. Vanessa Samuel, "TinyML: When Small IoT Devices Call for Compressed Machine Learning", May 27, 2020, at https://www.allaboutcircuits.com/news/tinyml-when-small-iot-devices-call-for-compressed-machine-learning/#:~:text=Smaller%20Devices%20Call%20for%20Compressed,%2C%20latency%2C%20and%20power%20consumption. Accessed on February 17, 2021.

shift in decision making and a distinct advantage over the adversary.[42] This will result in compression of combat time scales and the AI capacity to react will accelerate the pace of combat.[43] Analysts are questioning if this enhanced pace will have any operational benefit?[44] The existing military organisations will have to reorient themselves to accommodate increased use and concept deployment of autonomous systems like SWARMS in their area of responsibility. Processing of large amounts of data will provide out-of-the-box solutions, which at times may be out of human imagination at that instant,[45] especially during intense air combat. This will be a game changer to gain victory. Lastly, AI will give an upper hand in the entire battle domain with compressed time in decision making at all levels due to the AI machines' higher accuracy within its delegated sphere. High-risk missions and extended-time missions can be tasked by the forces to AI-driven platforms that cannot be performed by human-centric systems. This will minimise human casualties and justify AI's legal use in some high-risk operations. The possibility of concentrating the conduct of war to a small trustworthy group in autocratic regimes, such as China, would help the government gain greater control of the war by the elites.[46]

STRATEGIC AI

The balancing of conventional forces by the use of nuclear weapons by US against the USSR has been described as 'offset' strategy. The 'second offset' strategy was the development of information technology in the

42. John R. Allen and Amir Husain, "On Hyperwar", Proceedings 143/7/1,373 (2017): 30; "Getting to Grips with Military Robotics – War at Hyperspeed", *The Economist*, January 25, 2018, at https://www.economist.com/special-report/2018/01/25/getting-to-grips-with-militaryrobotics; Williamson Murray and MacGregor Knox, "The Future Behind Us", in The Dynamics of Military Revolution, 1300-2050 (Cambridge, UK: Cambridge University Press, 2001), p. 178. Accessed on February 21, 2021.
43. Greg Allen and Taniel Chan, "Artificial Intelligence and National Security", Belfer Center for Science and International Affairs, 2017.
44. Scharre, "Autonomous Weapons and Operational Risk"; Peter W. Singer, Wired for War: The Robotics Revolution and Conflict in the Twenty-First Century (New York: Penguin Press, 2009), p. 128.
45. The AI company DeepMind created a game-playing algorithm called AlphaGo
46. "Analysis: Artificial Intelligence Application in the Military | The Case of United States and China", at https://www.setav.org/en/analysis-artificial-intelligence-application-in-the-military-the-case-of-united-states-and-china/. Accessed on February 15, 2021.

1970s, and now AI is published in the US as a 'third offset'. All these technologies have affected the balance of power and transformed the strategic thought.[47] The literature on AI strategic signalling is scant, but parallels can be drawn from the nuclear and information strategy of nations. The AI's capability to instinctively group information and use this as a foundation for decision-making using deep learning will possibly have a flawless strategic convenience.[48] This however needs to be tempered in strategic-level decision-making, since the datasets will be ambiguous and generally uncertain for the AI algorithms to make decisions in any of the AI approaches.

AI has been attempting to develop the neural processes of human brains at a simplified level. The ability to learn without supervision, with limited training data, and to manage ambiguous and asymmetric information are the core research areas of AI. Once these technologies mature, AI will graduate from the strength of mathematical algorithms and pattern recognitions of machine learning to abstract intelligence.[49]

AI as an 'advisor' in strategy development will look at the traditional ideas in practice and offer the rationale of the thought process by processing the vast existing data. It can thereafter reject some theories and identify additional and new vulnerabilities of the adversary to frame a new strategy. The strategic AI will be insulated from the individual and collective thought processes in human decision-making.[50]

When fully operationalised, the AI systems will certainly change the structure of the battlefield and flatten the military organisation. The impact

47. Kenneth Payne, "Artificial Intelligence: A Revolution in Strategic Affairs?" September 18, 2018, pp. 7-32, at https://www.tandfonline.com/doi/full/10.1080/00396338.2018.1518374. Accessed on February 13, 2021.
48. Kareem Ayoub and Kenneth Payne, "Strategy in the Age of Artificial Intelligence", *Journal of Strategic Studies*, vol. 39, no. 5-6, 2016, pp. 793-819, at https://doi.org/10.1080/01402390.2015.1088838. See also Michael Horowitz, "Artificial Intelligence, International Competition and the Balance of Power," *Texas National Security Review*, May 15, 2018, at https://tnsr.org/2018/05/artificial-intelligenceinternational-competition-and-thebalance-of-power/; and Paul Scharre, Army of None: Autonomous Weapons and the Future of War (New York: W.W. Norton, 2018). Accessed on February 13, 2021.
49. Kenneth Payne, n. 47.
50. Ibid.

of AI on society as a whole will be more intense than that of the nuclear revolution and will extend far beyond military issues.[51]

CONCLUSION

The pace at which AI is acquired and barriers to its proliferation across the nations will decide the impact of AI on the balance of power. These are likely to be rapid and unevenly distributed among nations. AI will most probably impact the full spectrum of battle domains with no distinction between conventional and non-conventional systems.[52] AI in defence must be understood differently from believing that one's own capability enhancement will pose a security threat to the adversary. AI deployment is leveraging one's existing capabilities to improve combat potential, be it time compression in the OODA loop or efficiency and effectiveness of the operations.[53] Finally, does the AI impinge on the military commanders' unity of command? The local commander may approve the AI plans for execution. Is he fully aware of the AI plan and understands it before giving the go ahead? While the human in the loop system will undoubtedly persist, what about those without a human in the loop system? Who is in command? Thus, AI scientists and programmers have to be part of a joint team of military practitioners and strategists to accept a shared responsibility for the development and subsequent operationalisation of the AI system.[54]

Developments in field of AI are taking place at a fast pace. Military leaders will have to keep a close watch to be able to ride the wave to their advantage.

51. Ibid.
52. Ayoub and Payne, n. 48.
53. AI in Aerospace and Defense - Thematic Research ID: 4767179, at https://www.researchandmarkets.com/reports/4767179/ai-in-aerospace-and-defense-thematic-research. Accessed on March 6, 2021.
54. "How AI Could Change the Art of War Time-honoured principles of command get weird when you add the fundamentally alien thinking of an artificial intelligence", by Sydney J. Freedberg Jr., at https://breakingdefense.com/2019/04/how-ai-could-change-the-art-of-war/. Accessed on March 6, 2021.