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CENTRE for AEROSPACE & SECURITY STUDIES

MILITARY'S GUIDE TO ARTIFICIAL INTELLIGENCE

ISSUE PAPER 5

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Edited by Sarah Siddiq Aneel

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Abstract

This study explores the manifold domains in which Artificial Intelligence (AI) is having profound impacts in the contemporary world. AI is penetrating virtually every aspect of human life and changing the way we travel, use smartphones, and even interact on social media. Most of the applications of AI are dual-use, implying that they may be employed in both civilian and military settings. The huge potential of AI in the military domain has sparked competition for AI dominance and data control among key players in global politics such as the United States (US) , China, Russia and Israel etc.

AI has a plethora of applications in the aerospace industry such as real-time testing, safety monitoring, predictive maintenance, stimulation, air traffic communications and other combat related aerospace programmes. In Pakistan, the government, academia, and industry are all taking several initiatives to join the AI wave in order to remain competitive in a rapidly AI-evolving world. Using secondary data, this study highlights the current state of AI in general and in Pakistan in particular, and at the end puts forth recommendations for Pakistan to bridge the AI gap it has with the leading scientific and technologically advanced nations in the civilian as well as military landscape.

INTRODUCTION

Introduction

The Fourth Industrial Revolution (4IR) is characterised by emerging technologies such as robotics, quantum computing, cloud environment, the Internet of Things (IoT), and Artificial Intelligence (AI). These technologies are ushering humankind in a new era of economic disruption with uncertain socio-politico-economic and strategic implications. AI is playing a significant role in driving the 21st Century digital revolution. AI is defined as:

The theory and development of computer systems, able to perform tasks normally requiring human intelligence, such as visual perception, speech recognition, decision-making, and translation between languages.

-English Oxford Living Dictionary

Additionally, most contemporary definitions of AI describe it as a sub-field of Computer Science and how machines can replicate human intelligence.

Developments in AI are rapidly transforming daily life. Affordable and easy to comprehend AI software, integrated with core technologies, continue to achieve new milestones. From a technology demonstrator to applications in mobile phones, laptops, home/office appliances to air and space exploration systems, AI has come a long way in the last few decades.

Today, AI forms a part of daily life, with its applications easing routine as well as complex tasks, and making disruption a conceivable strategy for next generation wars. This trend is already visible in recent superpower standoffs and current conflicts.

While military developments in AI are apparently lagging due to stringent safety and reliability requirements, the civil sector driven by acquired funding through tech giants, continues her progression to new horizons.

The dual-use of AI technology also makes control of core tools challenging.

The race for superiority in AI technologies is also compounded by trade and technology wars between the US and China; with each, though pursuing similar objectives but digressing in approach towards AI development.

The US leads in militarisation of AI because of its almost perpetual military involvement in conflicts around the world, easy access to data and Research & Development (R&D) conducted by giant tech firms located inside or under the

control and/or influence of the government. The absence of international laws governing the use of autonomous AI controlled or operated weapons is also likely to encourage non-state actors towards acquiring disruptive technologies.

In this context, the study aims to furnish the reader with basic facts about AI development and fill the gap in literature pertaining to its dual-use application as well as challenges posed by it. Furthermore, the goal is to build awareness about AI developments, its civilian and military usages, warfare transformations, current limitations and propose a way forward for Pakistan. A separate section has been dedicated to the global race and aerospace sector due to its significance for next generation warfare.

Due to the vastness of the subject, it has been difficult to restrict the breadth of the study, as most areas of development and applicability in the civil and military domain are interlinked. The very nature of emerging avenues makes the study even more challenging as major developments are underway in the public sector with lenient proliferation controls. This aspect has potentially significant implications for national security as warfare is no longer restricted to the conventional domain only, but has proliferated to every aspect of society, affecting application of hybrid techniques. Every aspect of AI, from the definition part to warfare applications, both conventional and unconventional, continues to evolve and have deep implications for societies as well as states.

ARTIFICIAL INTELLIGENCE: TRANSFORMING LIFE SKILLS

Artificial Intelligence: Transforming Life Skills

AI being a part of 'Emerging Technologies' realm has a wide variety of applications, spread across almost all spheres of daily life. Nonetheless, in the classical scientific context, it can also be termed as a 'dual-use technology' having applications in both civil and military domains.

Virtually every application of AI from biometric/facial recognition technology, decision-making algorithms, data-based solutions and Lethal Autonomous Weapons Systems (LAWS) etc. can be used in the military sphere.[1]

The proliferation and control element of this development is difficult in today's environment, primarily because of unrestricted accessibility of civil AI technologies, devices, applications, and virtual assistants, which have already become a routine part of human life. In the prevalent environment, these technologies aim to assume all the mundane tasks that currently require expending valuable time, thus freeing resources to be more creative and perform essential work that earlier consumed numerous man-hours. In 2019, 56.1% of the world's population (approximately 4 billion) had access to the Internet and was exposed to some form of AI application.[2]

Due to market dynamics, investment and profitability issues, the private sector has taken the lead in developing and promoting AI technologies. Some of these technologies, in modified versions, are then utilised for military applications.

The proliferation aspect and use by non-state actors is another serious and petrifying dimension in the Hybrid Warfare domain. From the national security perspective, it is important to understand the capacity, permeation, expanse, and applicability of AI to comprehend the full impact of disruptive strategies. While the domain of AI use is fairly large, a brief explanation of a few of its dual-use technologies is necessary to understand the emerging challenges posed by it in its military application.

Robotics

Robots are one example of dual-use technology with extensive military

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[1] Jayshree Pandya, "The Dual-Use Dilemma of Artificial Intelligence", *Forbes*, January 7, 2019, https://www.forbes.com/sites/cognitiveworld/2019/01/07/the-dual-use-dilemma-of-artificial-intelligence/?sh=6c859596cf02.

[2] Shep Hyken, "Half of People Who Encounter Artificial Intelligence Don't Even Realize It," *Forbes*, June 10, 2017, https://www.forbes.com/sites/shephyken/2017/06/10/half-of-people-who-encounter-artificial-intelligence-dont-even-realize-it/?sh=2abfc1d4745f.

applications. Robotics is a huge industry with applications from manufacturing to home appliances. AI-powered robots can solve complex problems and as yet are capable of limited thinking processes. Examples of robots in the commercial sector are plentiful and range from robotic assembly lines in Tesla to robots teaching English to a class in Japan.[3]

However, use of autonomous robots in the form of robotic cavalry or Unmanned Aerial Systems (UAS) in the battlefield could become a dilemma as they would leave the developing countries, which lack equitable technology, at a grave disadvantage.

Self-Driving Cars

AI has disrupted the traditional automotive industry and is steering/pushing the development of a new generation of autonomous vehicles. With Tesla leading the way, self-driving cars are the future of road transportation. The systems in these cars also include 'Advanced Driver Assistance Systems' (ADAS), virtual assistance, natural language interfaces, camera-based machine vision systems, driver condition evaluation, sensor-fused Engine Control Units (ECUs) and radar-based detection units.[4] All these technologies are integrated seamlessly to enable safe and successful autonomous vehicle operations. The self-driving aspect is a model for autonomous vehicle development for military use. Similar technologies are being used in Unmanned Aerial Vehicles (UAVs), robots and autonomous sea vehicles.

Mobile Phones

The mobile phone industry is a model of technological progress, utilising state-of-the-art technologies and AI-powered tools for providing innovative services. Different features in smartphones rely on AI to perform their functions. For example, the new generation of smart personal assistants, such as Siri, depend on AI to fulfil their tasks.

The mobile phone itself is also a core tool of hybrid warfare, identifying data used by every user and providing access to classified installations at the touch of a button by identifying and activating optimally positioned microphones and cameras.

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[3] Sam Daley, "19 Examples of Artificial Intelligence Shaking up Business As Usual," *Builtin*, February 9, 2019, https://builtin.com/artificial-intelligence/examples-ai-in-industry.
[4] Lucas Mearian, "Here's How A.I. is about to Make Your Car Really Smart," *Computerworld*, June 14, 2016, https://www.computerworld.com/article/3083426/heres-how-ai-is-about-to-make-your-car-really-smart.html.

Social Media

Social media platforms like Twitter, Facebook, Snapchat etc. are increasingly employing AI to personalise user experiences. AI enables different features on Facebook such as messenger chatbots, ad targeting, photo tagging suggestions and algorithmic newsfeeds etc. to optimise user experience and enhance involvement in use of desired applications. Similarly, Twitter also uses AI to categorise, monitor and tailor user feeds.

Aided by AI, social media has emerged as the number one tool to execute Information Warfare and influence a user's thoughts, actions, and strategies.

Conclusion

AI developments in the civil sector continue to draw trillions of dollars in investment. Brilliant minds and start-ups around the world are being picked up by multinationals such as Google, Facebook, Tesla, IBM, and Apple. The developed AI applications and technologies are then sold in the open market for billions in profit.

The quest for profits and recognition has led to less focus on defence technologies which lags well behind the civilian AI sector. However, the dual-use of these technologies means quick adaptation towards military applications, especially for next generation warfare.

The proliferation of technologies in use at public/private workplaces and homes also paints a nightmarish scenario against data protection. The core area of dual-use AI progress in the civil sector is where government funding plays a major role in supporting military AI developments. Accordingly, organisations such as the Defence Advanced Research Projects Agency (DARPA) - an agency of the United States Department of Defense; the Russian Foundation for Advanced Research Projects (RFARP); British Defence Science and Technology Laboratory (Dstl) and the Chinese Central Military-Civil Fusion Development Commission invest heavily in emerging dual-use technologies for use by the military.

The use of AI in almost every field of daily life, especially e-governance and e-organisations, among others can be identified with a major exploitable vulnerability - where the entire project, programme or application can be remotely neutralised and the government / organisational processes damaged with disruptive AI application.

RACE FOR DATA CONTROL

Race for Data Control

The race for AI dominance and ultimately control of core technologies and data, is gaining momentum. Today, AI has become an area of fierce contestation between major powers, wherein the commercial sector is funding research amounting to billions of dollars. In 2016, the overall AI market size was valued at USD 641.9 million, with an expected rise of over USD 15 trillion by 2030.[5] According to estimates, the commercial R&D market is expected to grow by 42.2% in the 2020-27.[6] It is believed that US, China, and Britain are at the forefront of investing in AI, however, efforts for AI development are underway in many other countries as well. While some countries have announced their policies, plans and R&D funding vis-à-vis AI, investment in defence-related activities to a larger extent has remained opaque.

AI dominance will ensure substantial advantages (in multiple avenues) and profits for dominant players, however, it shall be the access to data, which will form the basis of primacy in developing future AI systems.

The aspect of control of proliferation or sharing of AI's technology will also have serious repercussions for the national security of developing countries, especially the ones that have weaker scientific and technological base.

Global AI Index

A new global AI index released in 2020 ranks 62 countries according to their AI prowess. These countries were measured across several key parameters including: 'talent, infrastructure, operating environment, research, development, government strategy etc. Each indicator was weighted for importance after consultation with experts across the field.'[7] The results are indicated in Figure 1:

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[5] Market Research Report, "Artificial Intelligence Market Analysis by Solution (Hardware, Software, Services), By Technology (Deep Learning, Machine Learning, Natural Language Processing, Machine Vision), By End-use, By Region, and Segment Forecasts, 2018–2025," (Grand View Research, 2017).

[6] Patrycja Mach, "How Can AI and Machine Learning Support Your Research & Development?," *Ideamotive.Co*, December 16, 2020, https://www.ideamotive.co/blog/how-can-ai-and-machine-learning-support-your-research-and-development.

[7] "The Global AI Index," *Tortoisemedia.Com,* 2021, https://www.tortoisemedia.com/intelligence/global-ai/.

Figure 1: Global AI Index Rankings

1	United States	→ 0
2	China	→ 0
3	UK	→ 0
4	Canada	→ 0
5	Israel	↑ 7
6	Germany	↓ 1
7	Netherlands	↑ 9
8	South Korea	→ 0
9	France	↓ 3
10	Singapore	↓ 3
11	Finland	↑ 3
12	Ireland	↓ 2

Source: "The Global AI Index."

The salient points of the report indicated that the US was far ahead of other countries in AI growth scoring, almost twice as much as China, which was placed second. However, with its current rate of growth, China is expected to overtake the US in a decade. Britain was placed third due to its academic reputation and vibrant AI talent pool. Russia, with limited research and human resource in the field of AI, was rated as a smaller country. Ireland, Israel, Netherlands, and Finland have developed vibrant AI economies. Israel climbed from 12th place to 5th, Netherlands 7th from 16th and Finland 11th from 14th.[8] Here, a brief exposé of AI developments in leading countries is being offered to understand the broad direction of future AI applications.

United States

Currently, the US is leading the AI race. On 'GitHub', the largest open-source development platform of the world, US based coders, over the past year, had made more than five times more code contributions than the 22 European Union

[8] "The Global AI Index."

(EU) countries listed on the platform.[9] The country's 'Networking and Information Technology Research and Development Program' was created by a multiagency task force, focusing on strategic priorities for IT (including AI).[10] The programme is focused on speeding up R&D to uphold her global dominance in the field and improve national defence and security. As part of the 'Third Offset Strategy', efforts are being made by the US DoD, mainly through DARPA, to out-manoeuvre advantages made by top adversaries, primarily through technology. DARPA is also engaging private corporations such as Google, Lockheed Martin, Boeing etc. in numerous joint AI development products. For a decade, the agency has also been conducting a competition 'Cyber Grand Challenge', with sizeable prize money. The incentive serves as a source of private funding in the AI sector, in order to promote innovation and harness the abilities of the private sector for governmental use.

The US 'Brain Research through Advancing Innovative Neuro-technologies' (BRAIN) initiative is a collaborative public-private multibillion-dollar initiative for AI research over the next decade.[11] While the existing conceptions of applications are limited, a growth in spending over multiple years implies that AI has acquired traction and progressed past the test and development stage.[12] Core AI development in the US is led by the private sector with global IT, media, and technology giants at the front. This global technology empire is supported by the world's top AI resources picked up from around the world at hefty pay packages.[13]

The US has also acknowledged its efforts to incorporate AI into defence systems and advanced weapons. In this area, the country has been actively engaged in drone warfare for the last three decades. All of its major weapon developments incorporate AI in one form or the other.

One example of militarisation of AI is 'Project Maven', which aims to employ 'machine learning and artificial intelligence' to differentiate people from objects in thousands of hours of drone footage. Contemporary status and extent of AI applications in US defense structure is classified, nonetheless, it can be believed

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[9] Alexandra Mousavizadeh, Patricia Clarke and Kim Darrah, "Europe Falls behind in the AI Race," *Tortoisemedia*, June 9, 2021, https://www.tortoisemedia.com/2021/06/09/europe-falls-behind-in-the-ai-race/. https://www.tortoisemedia.com/2021/06/09/europe-falls-behind-in-the-ai-race/.

[10] "AI Research Program Repository," Networking and Information Technology Research and Development Program, https://www.nitrd.gov.

[11] Shashi Shekhar Vempati, *India and the Artificial Intelligence Revolution*, ebook (New Delhi: Carnegie India, 2016), https://carnegieindia.org/2016/08/11/india-and-artificial-intelligence-revolution-pub-64299.

[12] *Department of Defense Artificial Intelligence, Big Data and Cloud Taxonomy*, ebook (California: Govini), https://securityandtechnology.org/wp-content/uploads/2020/07/govini_dod_ai_bigdata_cloud_taxonomy.pdf.

[13] "DARPA Demos AI-Powered Squad X Experimentation Programme," *Army Technology*, July 16, 2019, https://www.armytechnology.com/news/darpa-ai-squad-x-experimentation-prog/.

that in near future, all offensive and defensive systems' inventory of US DoD shall incorporate AI in some form.

China

China is pursuing a strategy to become the leader in AI technology by 2030. In this regard, the Chinese government has also released a roadmap highlighting a national policy to prioritise AI R&D; simultaneously acknowledging the will to undertake significant progress to plug the gap with other developing countries in terms of AI advancement.[14]

China's roadmap depicts her intention to invest and advance in all facets of AI, such as big data gathering, assimilation and processing, human-computer hybrid intelligence, cross-media awareness computing, swarm and group intelligence etc.

In addition to integrating and sharing civilian as well as military AI resources, the policy also mentions incentives for the AI industry including tax exemptions, zone allocations etc.[15] The country has also successfully demonstrated her capability of launching and controlling aerial drone swarms along with her capacity to produce kamikaze drones having explosive warheads.[16] It is at an advanced stage of expertise in AI-based military systems.

Russia

The Russian resurgence after the breakup of Soviet empire is visible through her aggressive policies towards the Western bloc led by the US and increased politico-military engagements in different global scenarios. Russia, like China, has expressed its intention of pursuing AI development vigorously, in order to ensure that the global balance of political, economic, technological, and military power does not tilt any further in favour of the sole superpower. The strategic direction for AI development was provided by President Putin, who called for the development of autonomous robotic facilities for the military.

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[14] Neel V. Patel, "China Plans to take Over AI in Three Easy Steps," *Inverse*, July 7, 2017, https://www.inverse.com/article/34515-china-releases-3-step-roadmap-for-a-i-revolution.
[15] "Artificial Intelligence Development Plan State Council Document [2017] No. 35," *Foundation for Law and International Affairs*, 2017, https://flia.org/notice-state-council-issuing-new-generation-artificial-intelligence-development-plan/.
[16] David Hambling, "If Drone Swarms are the Future, China may be Winning," *Popular Mechanics*, December 23, 2016, https://www.popularmechanics.com/military/research/a24494/chinese-drones-swarms/.

The 'National Centre for Development of Robotic Technologies' is to be established at the Advanced Research Foundation (ARF), with similar role as that of DARPA in the US.[17] Russian media has reported that the state's military is investing in AI-based robots, border protection systems, anti-drone systems and cruise missiles capable of analysing adversary tracking systems and taking appropriate response measures during their flight. Practically, it is very difficult to gauge Russian advancements in AI due to stringent state controls placed on concerning news.

Israel

With no international oversight over her activities, the Israeli defence industry has prospered under the US umbrella and technical patronage. The development has aided the unchecked development and ruthless testing of force with new weapons and techniques on the Palestinians.[18] Israeli military use of AI tools is expected to grow exponentially in the near future. The Israeli Defence Forces' (IDF) main technical team and the driving force behind majority of its AI developments is known as C4I directorate. The Sigma branch of C4I intends to develop and implement the most recent advances in AI and other technical faculties for IDF to stay up to date. The IDF uses weapon platforms that can operate with a significant degree of autonomy. The 'Harpy Loitering Munition' (LM), also known as a 'kamikaze drone', is one of the most relevant examples. It is a UCAV that has the capability to autonomously fly for long time and independently engage targets.[19] Israel was one of the first countries to reveal that 'it has deployed fully automated robots and self-driving military vehicles to patrol the borders with the Palestinian-governed Gaza Strip.'[20] Israel Aerospace Industries, one of Israel's largest arms manufacturing and exporting companies, has long been developing increasingly autonomous weapons. Due to its belligerent policies and lack of international monitoring, Israel is likely to be the lead proliferator of AI weaponry and Lethal Autonomous Weapon Systems (LAWS).

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[17] Samuel Bendett, "Here's How the Russian Military is Organizing to Develop AI," *Defenseone.Com*, July 20, 2018,
https://www.defenseone.com/ideas/2018/07/russian-militarys-ai-development-roadmap/149900/.
[18] Jonathan Cook, "'The Lab': Israel Tests Weapons, Tactics on Captive Palestinian Population," *Washington Report on Middle East Affairs*, August 12, 2013,
https://www.wrmea.org/013-september/the-lab-israel-tests-weapons-tactics-on-captive-palestinian-population.html.
[19] "Harop Loitering Munitions UCAV System," *Airforce Technology*, July 2, 2015,
https://www.airforce-technology.com/projects/haroploiteringmuniti/.
[20] Tomoko Ohji, "The Future of War: Israel First to Deploy Fully Automated Military Robots," *Mainichi.Jp*, August 24, 2016,
https://mainichi.jp/english/articles/20160824/p2a/00m/0na/020000c.

Conclusion

The investment-led developments in AI around the world may seem beneficial solely to civil-AI setups but they are also propitious in the military domain. Previously, many core technologies were developed through 'strategic technical alliances' that played a major role in Transfer of Technologies (ToTs) and in many cases, joint product development.[21] In certain cases, depending on the geostrategic environment, political and military alliances were also converted into technology cooperation. However, this is not the case for development of AI capabilities, where countries jealously guard and control software, encryption techniques, source codes etc.

Many technologies in AI are dual-use and necessitate the involvement of militaries in a civil-military AI fusion model.

Many tech-leaders in AI have already developed technologies / programmes with a hope to gain advantage over their opponents and keep others under pressure. With the growing interest and increasing investment by different countries, an AI weaponisation course seems to be emerging that is intimately linked to autonomous weapons systems.

Similar to the nuclear arms race of last century, militarisation of AI poses a threat to international geostrategic stability. The absence of international laws in controlling development of AI technologies have led to secret AI programmes which may raise harmful AI proliferation and application issues.

The AI race also brings into question the issue of technology control which is already visible in tech giant wars over key future technologies and the emergence of a broad technology schism that goes beyond the internet. Trade wars are already accelerating efforts for complete virtualisation and thus, control of emerging disruptive technologies is likely to affect national security.[22]

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[21] Juhaini Jabar, Claudine Soosay, Fararishah Abdul Khalid, Haslinda Musa and Norfaridatul Akmaliah Othman, "The Role of Strategic Technology Alliances (STA) towards Organizational Performance in Manufacturing Industry: The Perspective of Developing Countries," *Asian Social Science* 11, no. 16 (2015), doi:10.5539/ass.v11n16p38.

[22] Tim Bajarin, "China's Efforts to Control their Technology Future and its Far Reaching Impact," *Forbes*, July 19, 2019, https://www.forbes.com/sites/timbajarin/2019/07/19/chinas-efforts-to-control-their-technology-future-and-its-far-reaching-impact/?sh=7ffab1ddfa84.

AI AND THE AEROSPACE SECTOR

AI and the Aerospace Sector

One of the major beneficiaries of AI innovations is the aerospace sector. This is because of the core compulsion of Aerospace discipline that makes it a prerequisite to continuously remain engaged with a highly competitive market, technological breakthroughs, and geopolitical challenges, brought about by an ever-evolving world.

The high performance and extraordinary reliability demands of extremely complex engineering systems, utilised in aerospace industry, has obligated the employment of AI as an imperative. Consequently, in the drive for revenue generation and operational efficiencies, AI has made phenomenal progress in most domains of aerospace including design, manufacturing, testing, flying, maintenance, supportability, predictive fault analysis, resolution alternatives or preferences, traffic management, flight safety, and passenger convenience.

Amongst various domains, the civil aviation sector, which is primarily driven by profitability requirements, leads the way in adapting to upcoming AI modules. Latest research indicates that 97% of defence and aerospace industrial conglomerates are willing to transform their industry and businesses.[23] The modules adopted in civil aviation sector also find their way to space and military applications. A closer look at AI usage in various aviation sectors presents useful conclusions and defines a way forward for future AI development in entire aerospace domain.

Aviation Products Testing and Safety through Real-time Monitoring

AI has made real-time health monitoring of systems both on ground and in air possible through small nano sensors installed on every part of the aircraft and its surrounding operational and technical areas. Anomalies such as variations in temperature and pressure datum, various physical, thermal, stresses and systems' deviation(s), can be detected, measured and remedial actions initiated before onset of any malfunction. Physical safety checks and inspections are conducted by AI controlled systems once the aircraft land. Testing processes are now shifting to comparison of an ideal database with the results achieved during testing. This real-time monitoring has exponentially enhanced safety margins, especially during critical flight testing of new aviation products.[24] This aspect is also critical to UAV

[23] Accenture, "Artificial Intelligence in Aerospace and Defence", https://www.accenture.com/_acnmedia/PDF-82/Accenture-Artificial-Intelligence-Aerospace-Defense-Ambition-Action.pdf.
[24] Mike Gerdes, "Predictive Health Monitoring for Aircraft Systems Using Decision Trees," (Licentiate diss., Linköping University, Linköping, 2014), https://www.diva-portal.org/smash/get/diva2:711210/FULLTEXT01.pdf.

testing and stress monitoring throughout the product lifespan, as certain infight anomalies may be missed due to absence of a pilot in the systems.

Platform Monitoring and Predictive Maintenance

Predictive maintenance, as opposed to preventative maintenance, removes guessing by mathematical forecasting equipment problems in real time. By meticulous monitoring the electro and mechanical systems in an aerospace platform and adopting the appropriate repair procedures based upon predictive AI-driven software, AI can also greatly help in reducing unprecedented system problems.[25]

AI algorithms can now identify the instance where maintenance is needed even before a component fails, allowing faster fixes and lesser grounding time. AI might eventually be incorporated in all platform systems to extend the lifespan of parts, reduce disruptions, and save operators unrequired expenditure. AI systems, using natural language processing, can analyse millions of maintenance logs to forecast component trends and failures, and suggest corrective actions.[26] This aspect is also vital for unmanned systems and could substantially facilitate in development of Lethal Autonomous Weapon Systems (LAWS).

Simulation

AI has transformed training in all aerospace spheres through application of advanced simulators. Various training disciplines include ground handling, defect testing, maintenance, flight crew training etc. The true potential of AI lies in pilot training for unmanned systems, where AI autopilots facilitate managing multiple operations and response to unfolding complex contingencies in the air. Beside gaining proficiency in flying, phase-training and inflight emergencies' handling with AI help; airline pilots learn crises management through AI systems that were developed through machine learning and duplication of past actions, performed by well-trained pilots, in similar circumstances.[27] Similarly, AI training regimens now allow pilots to train more according to standards and less according to instructor's subjectivity. The USAF's 'Pilot Training Next' programme uses AI, virtual reality systems and advanced biometrics in simulators to identify new ways to teach

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[25] Autonomous Manufacturing, "AI & Aerospace: 5 Ways Artificial Intelligence Could Impact Aviation," August 31, 2018,
https://amfg.ai/2018/08/31/ai-aerospace-5-ways-artificial-intelligence-could-impact-aviation/.
[26] "How Artificial Intelligence is Changing the Aviation Industry," Blog, *Social Hospitality*, August 2018, https://socialhospitality.com/2018/08/how-artificial-intelligence-is-changing-the-aviation-industry/.
[27] Eric Adams, "AI Wields the Power to Make Flying Safer—And Maybe Even Pleasant," *Wired,* March 28, 2017, https://www.wired.com/2017/03/ai-wields-power-make-flying-safer-maybe-even-pleasant/.

pilots, employing emerging technologies to reduce time and cost without reducing learning depth.[28]

Air Traffic: Simplifying Control and Communications

In busy sectors, air traffic systems generally operate at its performance limits. Therefore, accommodating future Air Traffic Services (ATS) growth will be a challenge for ATS providers. Accordingly, the existing airspace control capacity needs to significantly expand without increasing workload of limited but skilled human resource and Air Traffic Control (ATC)'s cognitive capabilities. New AI paradigm increases the capacity of anticipation and decision-making in complex, uncertain environments.

AI systems have high potential for managing heavy air traffic density, particularly in areas involving deliberated decision-making, such as during trajectory prediction, conflict detection and resolution, with limited available information.

Similarly, in ATC, flight routing, tracking and communications are critical aspects of airspace management. In different air control centres, much conversation happens in heavily accented language, making it difficult for pilots and controllers to understand each other. Cleaning up air traffic conversations is difficult for machine learning algorithms because ATC audio is usually noisy and the conversation is fast, that too in aviation specific language. The AI programmes have allowed the resolution of such issues to make instructions clearer and unambiguous. With the development of these tools, AI has become an integral part of air traffic management operations.[29]

AI Use in Space Programmes

AI has been a part of formal space programmes since its inception in the last century, in one form or the other. AI applications for space programmes vary from data analysis to actually controlling satellites and space systems to using robots for planetary explorations. With constant influx of data, complete reliance on human intelligence, which is prone to distractions, is problematic. Accordingly, AI applications provide outcomes with few negligible errors while significantly

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[28] BAA Training, "Artificial Intelligence Putting Roots in Aviation," October 29, 2018, https://www.baatraining.com/artificial-intelligence-putting-roots-in-aviation/.
[29] ICAO, *Thirteenth Air Navigation Conference,* report (Montréal: International Civil Aviation Organization, October 9-19, 2018, Doc 10115, AN-Conf/13), http://www.icscc.org.cn/upload/file/20200603/20200603135246_36312.pdf.

enhancing safety operational gains and crystallising desired results.

AI will accordingly be a major player in space-based and space-employed military operations.

Latest example of such a programme is the robotic helicopter 'Ingenuity' that independently flew in atmosphere of planet Mars in April 2021.

AI Robots in Space

Nearly all robots in space are AI controlled. These vary from robots for communication, systems' maintenance, navigation, flight control/monitoring, planet exploration, sample collection, data analysis etc. The technology took a step forward with the introduction of CIMON (Crew Interactive MObile companioN), a five-kilogram, technology demonstrator with AI-based knowledge and personality, to interact with the crew and assist with scientific experimentations. CIMON is able to process texts, languages, images, as well as recognise crew members and improve human expertise through understanding of complex data. CIMON is designed to test the interactions that machines can have with humans in outer space. Besides the basic functions, it can search for objects, do inventory management, document experiments, take photographs and record videos.[30]

AI use in Drones

Almost all application of AI, utilised in civil aviation and space domains, has found matching roles in civil and military drones. This is because of the involvement of civil aviation technology giants in military aviation products. All leading aerospace companies collaborate closely with their military counterparts. Accordingly, military aviation benefits from technological prowess exhibited in the civil sector.

In the last decade, uninhabited aircraft technologies utilising AI have proven their worth in multiple domains. From commercial utility in aerial photography to parcel deliveries to remote medical monitoring, UAVs and drones are no longer alien for society. Agriculture, construction, inspection of oil and gas assets, surveillance, search, and rescue for people etc. are just a few examples of fields enjoying AI applications.

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[30] IBM, "CIMON Brings AI to the International Space Station," https://www.ibm.com/thought-leadership/innovation-explanations/cimon-ai-in-space, Accessed April 26, 2021.

Conclusion

While AI and its offshoot technologies have a lot of potential in aerospace, they are still in formative stage of development. This is, in part, due to strictest safety measures that are vital in a highly regulated industry like aerospace. Any new technology introduced in aviation sector must pass through extensive validation and certification processes. However, AI being a complex and emergent system capability, currently does not possess the precise testing equipment and procedural tools to pass through the traditional certification processes. Therefore, an innovative and efficient verification processes needs to be introduced, for AI to reach its full potential in the aerospace sector.

Amongst various challenges that AI faces in the aerospace sector, is the challenge of data management. Data being the fuel of AI software, drives the intelligence of computer algorithms. The accuracy, detail and enormity of data determines the precision in output of AI. Modern airline autopilots and safety systems, using AI software, take input from multiple sensors placed around the aircraft. Nonetheless, presently pilots do not depend totally on AI to operate their aircraft; as the capacity of AI to deal with anything out of the ordinary is unsubstantiated. Also, owing to the reasons narrated above, it is beyond the current capacity that any operator could hand the lives and safety of so many passengers to a software application, no matter how advanced that could be. Overall, however, despite these limitations, AI application in the aerospace sector is growing at an unprecedented pace.

STATUS OF AI IN PAKISTAN

Status of AI in Pakistan

As the world's leading countries continue to adopt advance AI practices, Pakistan is now awakening to utilise AI in furthering her technological progress and advancing scientific prowess. The lack of awareness, want of initiative and inconsistency in policy towards scientific development can be attributed to the dismal state of technology and industrialisation in the country, which has been marred by the energy crisis, an unsteady economy and political instability. The Armed Forces, however, adopted AI use in less sensitive areas and examined the possibility of expanding AI applicability in other operational domains. Globally, in the last two years, comprehension of AI potential has also found countries formulating strategies to promote its use and development in all related fields, including military. The list of these countries includes technologically advanced nations such as Canada, Denmark, France, Japan, Singapore, UK etc. India established an AI task force in October 2017.

An analysis of most AI strategies implemented by advanced countries reveals that 'scientific research, talent development, skill, education, public-private sector adoption, ethics, standards, regulation of data and developing digital infrastructure' formed the bedrock of their national AI policies.[31]

From Pakistan's perspective, it is important to assess its long-term strategic priorities. Some of these priorities have been enunciated in Pakistan's 'Vision 2025' document to a certain extent. Key enablers in the vision document include 'developing human and social capital, achieving sustained indigenisation and inclusive growth, democratic governance, institutional reform and modernisation of public sector.'[32] While catering for national objectives, the vision does not specifically encompass any AI strategy to further national security objectives or address challenges emerging from a volatile neighbourhood in a networked world.

In this context, there has remained a policy vacuum vis-à-vis development of AI in Pakistan, and subsequent progress and proficiency in this exceptionally important emerging technological realm, in the country.

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[31] Holon IQ, "The Global AI Strategy Landscape," April 25, 2019, https://www.holoniq.com/notes/the-global-ai-strategy-landscape.

[32] MoPD&R, *Pakistan 2025 One Nation - One Vision*, report (Islamabad: Planning Commission, Ministry of Planning Development & Reform, Government of Pakistan, 2018), https://www.pc.gov.pk/uploads/vision2025/Pakistan-Vision-2025.pdf.

Nevertheless, the government, academia and the defence forces of Pakistan have recently taken important steps to build AI-related infrastructure in the country.

Government Initiatives

In 2019, the 'Digital Pakistan' was launched, a governmental initiative aimed at introducing latest technology for public welfare.[33] President's Initiative for Artificial Intelligence and Computing (PIAIC) and the National Centre for Artificial Intelligence (NCAI) were also announced to stimulate the advancement of AI in Pakistan. The government launched PIAIC in 2019, to promote education, research, and business in AI. Through these initiatives, the government aims to transform Pakistan into a hub for AI, data sciences, augmented reality, blockchain, edge computing, cloud native computing and IoT. Currently, three one-year programmes on AI, cloud native and blockchain are being offered under PIAIC.

NCAI was launched in 2018 to spur the growth of AI research in Pakistan under the government's 'Vision 2025'. The initiative aims to make NCAI 'a leading hub of innovation, scientific research, knowledge transfer and training to local economy, in AI as well as in its derivative fields.'[34] The project was launched with a funding of a PKR 1.1 billion, which was to be consumed in the next three years for developing and operating labs located in six top universities of Pakistan. Under the project, Deep Learning Lab and Intelligent Field Robotics Lab was established at NUST, Islamabad; Medical Imaging and Diagnostics Lab at CIIT, Islamabad; Smart City Lab and Neuro-Computation Lab at NED, Karachi; Intelligent Criminology Lab at UET, Lahore; Agent-Based Modelling Lab at Punjab University, Lahore and Intelligent Information Processing and Intelligent System Design Lab at UET, Peshawar.[35] HEC and Planning Commission of Pakistan jointly selected these labs and their respective principal investigators through a rigorous selection process.

Initiatives by Academia

NED University, Karachi established the Research Centre for Artificial Intelligence (RCAI) in 2016 for promotion of theoretical and applied knowledge of AI in academia and industry, and to assist in policy-formulation and planning.[36] The centre aims to promote and contribute towards AI in Pakistan. It also aims to provide

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[33] "PM Imran Launches 'Digital Pakistan' Initiative,", *Express Tribune,* December 5, 2019, https://tribune.com.pk/story/2112360/1-digital-pakistan-pm-imran-addresses-launch-ceremony.
[34] "NCAI opens at NUST," *Business Recorder,* March 17, 2018, https://fp.brecorder.com/2018/03/20180317352348/.
[35] "Field Open: Iqbal urges Youth to Explore Artificial Intelligence", *Express Tribune,* March 17, 2019, https://tribune.com.pk/story/1662287/1-field-open-iqbal-urges-youth-explore-artificial-intelligence/.
[36] Research Center for AI, https://www.rcai.pk/, Accessed March 21, 2021.

training base at various academic levels and offers consultancy support to both industry as well as government, in addition to maximising Pakistan's participation in international AI community. The research centre targets application areas in building infrastructure, robotics, transportation, decision support systems etc. for national institutional planning in the fields of water and food resources, finance, security systems, energy, smart grid, and cyber security. This also allows RCAI to create integrated solutions including, hardware and software.[37] IBA has also established its research centre on AI to produce and contribute knowledge to the field. The lab has been functioning since 2009 and aims to serve as a forum for development of intelligent systems and generating discussions on emerging technologies within the field of AI.[38]

Furthermore, an encouraging development in the domain of AI is that a number of other leading universities such as NUCES-FAST, Air University and Centre for Advanced Studies in Engineering (CASE) etc. have started offering BS degree in AI. It is a welcome and much needed step in the right direction as it would aid in building future indigenous human resource specialised in AI. The students studying AI in these universities today, would be the leaders of the field tomorrow.

Initiatives by the Defence Forces: PAF Leading the Way

Pakistani military is well familiar with AI dividends and remains abreast with technology as a compulsion of living in a challenging neighbourhood. For any air force, which strives to maintain technological advantage, it is an obligation to remain updated. The Pakistan Air Force (PAF) established the Centre of Artificial Intelligence and Computing (CENTAIC) in 2020 to integrate AI in modern air warfare arena. It is meant as 'the vanguard of AI development in the country for both military and civilian purposes, enabling the PAF to integrate AI into its operational domain.'[39] It would also pave the way for Pakistan to sign bilateral and multilateral R&D initiatives with different countries promoting the exchange of learning and experience in AI technology. CENTAIC will explore key domains of AI including 'Big Data, Machine Learning, Deep Learning, Predictive Analysis, and Natural Language Processing (NLP)' as well as drive the development of PAF's fifth-generation stealth fighter jets, Medium-Altitude Long-Endurance (MALE) Unmanned Aerial Vehicles (UAVs), and other advanced weapons under Project Azm. AI could be employed

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[37] Ahsan Nisar, "The Pros and Cons of Artificial Intelligence in Pakistan," *Pakistan & Gulf Economist*, July 9, 2018, https://www.pakistangulfeconomist.com/2018/07/09/the-pros-and-cons-of-artificial-intelligence-in-pakistan/.
[38] Khurram Shahzad, "Boosting Pakistan with Artificial Intelligence," *Daily Times*, November 17, 2018, https://dailytimes.com.pk/322868/boosting-pakistan-with-artificial-intelligence/.
[39] PAF establishes Center for Artificial Intelligence, *Profit,* August 31, 2020, https://profit.pakistantoday.com.pk/2020/08/31/paf-establishes-center-for-artificial-intelligence/.

in Project Azm for several applications such as algorithms for guidance systems for air-to-air and air-to-surface missiles, image processing for TV/IR seekers, and Human-Machine-Interfaces (HMI).'[40]

Conclusion

Pakistan, with a booming population of over 220 million is rapidly digitising. The number of people using Internet in the country grew nearly 25% between 2018 and 2019, making Pakistan one of Asia's fastest-growing internet markets. The data also reflects the growing thirst for digitalisation and tech savviness of Pakistani youth, many of whom work on AI systems and software development in the country and abroad. However, for moving to the next level, Pakistan needs to develop a technological ecosystem and revamp its outdated education system. The academia-industrial linkage needs to be strengthened to accrue true benefits of the AI surge.

The government policies introduced in the last two years are designed to speed up digitalisation but need to be implemented with truest sincerity and dedication. It is also absolutely necessary to plug the AI brain drain, which is seriously impeding development in the ICT sector. Moreover, without adequate hardware manufacturing capability and software control, Pakistan would remain dependent on foreign sources for its critical cyber security requirements. The country also needs to speed up its collaboration efforts with world AI leaders especially China; both in terms of learning experience and induction of systems.

At present, it would be prudent for defence forces to only invest in indigenous AI systems, which guarantee data security and tamper free, reliable operations. Today, Pakistan also has some of the top-notch software houses that are paving the way for innovation in the field of AI. This talent needs to be retained, encouraged, and supported to contribute at the national and international level.

[40] Ibid.

RECOMMENDATIONS

Recommendations

Owing to the unbelievably rare and formidable prospects that AI offers, there is an aggressive R&D race between techno-leading powers, inter alia, US, Russia, China, UK, France, Japan, Germany, India etc. It has been noted that the states that would succeed in realising the benefits of AI, while reasonably managing the risks of the technology, would have a competitive advantage over their rivals in nearly every field. In the foreseeable future, countries with mature and controllable AI architect would enjoy the same advantage over lesser AI advanced states as those of industrially advanced states over non-industrial states. Any lag developed would be hard to bridge, as the 'haves' would not share their technological advantage and intellectual property free of cost.

Pakistan must immediately initiate essential measures in order to timely acquire the crucial technological knowledge base and develop necessary infrastructure to reap the benefits offered by AI. Owing to the availability of a large volume of data - which is a prerequisite for AI technology – Pakistan is placed in an ideal position to acquire, develop, and advance AI capability and capacity. It also means that by virtue of capitalising on its data resource, Pakistan could become an integral part of the international digital revolution. Decisions based on empirical evidence are infinitely better than those on intuition and anecdotal evidence. The tragedy is that the World Bank and IMF use the country's own data to suggest policy changes, while the government is unable to do the same, nor is able to anticipate what harm these suggested policies could do.

Pakistan needs to develop a robust 'National AI Policy' to advance and develop AI in the country. This policy would not only create favourable and encouraging domestic AI environment (with inward/outward option of transfer of technology) but also provide wide scope of joint ventures (JV) and international collaborative projects in Pakistan; while safeguarding own interests and regulating unfettered outside access to own data.

In this context, following frameworks are suggested for important pillars of the state, including the government, academia, private sector, and the Armed Forces.

Recommendations for the Government

1. The Government of Pakistan (GoP) needs to initiate the most urgent measures to address the existing lag and stagger in our national strife towards AI.

An expert body consisting of elected parliamentarians (federal and provincial), academicians, industrialists, software engineers, bureaucrats and personnel from the defence forces can be constituted, with head of Senate Committee on Science and Technology in chair, to prepare and present a policy framework.

The aforementioned policy may include proposed infrastructure at federal & provincial levels, practical and workable policies governing their tasks, industrial and academic initiatives, timelines, accountability processes, future courses, selected goals, etc. – for rapid development and advancement of AI in the country. This framework may be called the ***'National AI Policy (NAIP).'***

2. For effective and structured application of the policy:

An 'Artificial Intelligence and Computing Division' may be created under Ministry of Science & Technology at federal level. However, this division may have its provincial directorates, working under provincial administrative structures but operating under the federal framework of national AI development plan.

The Federal Division should be led by a world-renowned Pakistani origin AI professional – a technocrat who has the knowledge and experience of subject requirements, intricacies, impediments etc. The department could comprise of 55% AI professionals, 35% social scientists and 10% administrative or secretarial human resource. The division should independently explicate its goals and objectives, with timeline milestones, within the scope of NAIP. In other words, the department and its personnel should have clear foresight as to how, why, when and what they aim to achieve through function of AI applications. Formulation of an elaborative yet precise strategic framework for attaining the objectives specified in NAIP would be the foremost responsibility of this division.

3. Parliamentary oversight must be maintained through abovementioned committee over activities, progress, and milestone achievements of newly formed 'AI & Computing Division'. The committee should also monitor, evaluate, and review the progress made on enunciated policy and tasks by the division on a regular basis to gauge its performance and progress of AI in the country. This would not

only aid in assessment of effectiveness of the newly created division but also provide timely feedback and corrective options to review the newly drafted NAIP. Similar provincial representative committees may also be formed for monitoring and guidance at respective provincial levels.

4. A national endowment for AI, set up to the tune of a few billion rupees, would indicate the government's commitment in pursuit of this field. The same may also be used for basic funding or as seed money to new start-ups and young entrepreneurs, focusing on encouragement and stimulation of development of AI technology in Pakistan. This would also help in creating research as well as entrepreneurship opportunities in this novel field.

5. Pakistani nationals working abroad in the field of AI could be persuaded to return to the country, to share their knowledge and transfer skills; thus, hastening in-country development in the field at a faster pace. This could be done by offering them better incentives in the form of handsome pay packages, career advancement and other business opportunities. The arrangement could also be on temporary or permanent relocation basis, at the convenience of both sides.

6. Pakistan also has a large pool of graduates in IT, Computer Science, and other overlapping fields, who have migrated to Western countries in search of better learning, experience, job opportunities, etc.

This brain drain could be prevented by placing a mechanism for retaining these bright minds in the country. This could include offering financial and career progression incentives to young entrepreneurs and job seekers.

7. Different types and levels of infrastructural facilities and resources are required for development and use of AI (supercomputers being a case in point), to process large volumes of data (big data). The government needs to ensure that the access, availability, and relaxed import of such resources is possible through higher education and research institutions that are engaged in R&D in the field of AI.

8. The government also needs to contemplate, create, and implement policies ensuring that procedural, fiscal or administrative impediments do not impinge upon development and advancement of AI in Pakistan.

The relevant state institutions should ensure the preclusion of bureaucratic bottlenecks, systematic inertia and ensure that Pakistani AI researchers are given unhindered access (soft & hardware accessibility) to big data so that they can work efficiently.

9. Apart from emphasis on policy initiatives focusing on learning, developing, and adapting AI skills; indigenisation of hardware for local production and development of AI related microchips / boards / circuitry etc. also needs to become part of the policy initiative.

Development and manufacturing of indigenous advanced computing and data management hardware systems needs to be taken up as a strategic national compulsion.

10. With advancement in the field of AI, criticality and importance of data increases as do chances of data theft and hacking. Therefore, data protection policies and laws need to be enacted by the government that would provide a domestic as well as international legislative framework governing the collection and use of Pakistan's data. The laws shall have provisions, explicating offenses, and punishments in case(s) of violation(s).

11. The GoP may constitute an autonomous 'Data Protection Authority', responsible for protection of data and creation of a transparent system regarding rights, privileges, responsibilities, access, use, sharing, storage, security etc. of data. The Authority can:

- enforce protection of personal, public, classified, and private data,
- create awareness of the importance of data protection,
- prevent any misuse of any kind of data and entertain complaints regarding infringement of data laws,
- devise registration mechanism and formulate Licensing Framework for data access, collection, sharing, controlling, processing, security etc. at personal, institutional, private/public organisational or official levels,
- act as a conduit between various public and private organisations helping them acquire essential data legally, and,
- act as a bridge between academia and industry, facilitating R&D while simultaneously assuming a client role by gathering inputs from academia and industry partners in improving existing regulations/laws.

Academia's Path for Leapfrogging in AI

It is imperative for Pakistan to initiate simultaneous conduct of both, basic and advance research, in the field of AI.

Basic research would not only pledge learning for newcomers in the field but would also create new elementary knowledge for the beginners to consolidate upon. Applied research can also build on new ideas from basic research and aid in, for instance, creating new structures, resolving specific problems, modifying existing AI products etc.

Therefore, the academic community of Pakistan needs to take up this national cause and become drivers in advancing AI knowledge and applications in the country. Following measures are proposed in this regard:

1. Realising that AI education should start as early as high school, top universities should organise activities to reach out to high school students. Though NUST has previously conducted a summer camp on AI, more universities need to follow suit in order to stir curiosity and intrigue young minds through greater awareness and progression prospects.

2. In addition to universities summer camps, high schools could also pilot AI awareness programmes through their IT classes. Schools could partner with related tech universities and companies to initiate, steer and satiate students' curiosity towards AI. Subjects for pilot classes could include AI ethics, autonomous robotics, AI programming, AI applications' prospective fields etc. This detailed exploration of the AI spectrum would not only help students easily comprehend AI and its applicability in the real-world but also aid academia in simultaneous evolution of AI scientists in technical and ethical fields.

3. Pakistani institutions need to build strong academic ties with leading international AI research institutions. Taking into consideration that internationally, major investments are being made in AI research, mainly by China and the US, Pakistan can capitalise on its close relationship with the former and seek collaboration in all fields of AI from academic to research and products etc. The China-Pakistan Economic Corridor (CPEC) can serve as a platform to enhance technological collaboration and include establishing high-tech AI specific educational institutions / product-lines in Pakistan. This simultaneous move on subject learning as well as product manufacturing would be help in leapfrog development in AI. Similarly, academic cooperation with the US or other Western universities may be pursued regardless of specific AI branch or subject.

At this moment, learning of AI from different schools, perspectives and technologies is more important than choosing specific disciplines / topics.

4. It is essential for Pakistan to plan and prepare, through a strategic arrangement, a large community of accomplished professionals who possess the essential skills to develop and optimally employ AI in every arena. This can be only possible through introduction of new AI disciplines, degree programmes and specialised courses in universities starting from undergraduate level.

Introduction of undergrad degree in AI in all leading universities of Pakistan could be a pivotal step towards the advancement of AI in the country.

5. Higher Education Institutions (HEIs) in Pakistan can also introduce inland condensed trainings, short courses, diplomas in AI, etc. in order to educate and train people with a university certificate/diploma/degree or equivalent qualification in any relevant AI field. In this regard, a special scholarship scheme may also be commenced by the Higher Education Commission (HEC) for students who desire to pursue short courses or higher studies (Masters or PhD) in emerging technologies such as AI, Robotics, Computer Science, etc. in leading universities of the world. When these scholars return, they can share their knowledge and experience with others in the field; and execute advance research in their respective fields in addition to taking up teaching in academic institutions for training of next generation of AI specialists.

More importantly, Pakistan needs to institute measures to develop ethical policies, norms, principles, and rules in order to guide a morally correct and legally just use of AI while training the next generations in use of a technology that can be used for common good of humanity.

Industry Contributions towards National AI Effort

Currently, academia and industry in Pakistan are working on AI in silos.

The academia-industry disconnect needs to be bridged by taking initiatives, such as building technology parks, where all subject-related academics, experts, professionals, and entrepreneurs can come and work together to create new opportunities and surmount existing challenges.

While the prime responsibility of arranging these joint projects would remain with the government, initiatives by the academia, industry or private sector would be mutually beneficial, thereby strengthening national AI capacity.

1. A robust collaboration developed between the public sector, private business houses and academic institutions (that are undertaking research in AI) would be of paramount importance to every entity, as its benefits would be jointly harvested by all partners through gains in knowledge, financial benefits, experience, and many other fields of commercial and technical arenas. This could be done through project funding, joint projects/ ventures, scientist/researcher exchange programmes (between universities, research institutes and tech corporations) etc. A collaborative model between universities, in sharing resources and experiences, may provide useful exposure to IT, Computer Science and AI graduates.

2. Pakistan needs to earnestly revive its computer manufacturing industry which has fallen prey to governmental negligence and lack of local industry and market support. At present, only 1% of a huge market demand is fulfilled by local manufacturers. In early 2000s, there were more than 20 local manufacturers of computers in Pakistan. However, unfavourable government policies and lack of private industrial/commercial support proved fatal for the sector. Pakistan hosts a multimillion-dollar market for computer hardware but the need is usually fulfilled by the low-priced, used PCs classified as 'electronic waste', dumped by Western countries. These PCs provide for 60% share of the local hardware need, while the remaining demand is fulfilled by the international brands, capturing major market share in the country.

In terms of physical capacity enhancement, indigenous development of a supercomputer needs to be taken up as a national strategic project on the highest priority.

Way Forward for Pakistan Armed Forces

An earliest acquisition, adoption and integration of AI is the most important prerequisite for any technology dependent organisation, such as Armed Forces. Modernisation in operational military thought during the last decade of the previous century has meaningfully altered the development of doctrines of employment of respective services.

Concepts like targeting 'concentric circles of centre of gravity' (Warden's Rings), physical/psychological paralysis (Boyd's OODA loop), Effect Based Operations (EBO) etc. have underscored the importance of innovation and technology against a quantitatively larger enemy. In the same connection, multiplicity of options and means available in emerging technologies, especially AI, to a bright mind can be best employed by a smaller force against a larger one.

In this regard, one must remember that AI is not just 'a' domain but an array of technologies that can be arranged/amalgamated into a large assortment of applications; thus, bringing in unimaginable transformation in tempo, intensity, and lethality of war beside inducing complexities like ethics, humanitarian consequences, escalation etc.

The present state of development of AI in Pakistan is really worrying, especially when viewed against other South Asian neighbours. India, in contrast (owing to numerous external / internal factors) has enjoyed unlimited access to this sensitive and formidable knowledge domain. Rise of Indian diaspora to the top-most slots of globally leading tech giants is a manifestation of her access and adeptness in this field. Pakistan (in general) and Pakistan Armed Forces (in particular) have to adopt parallel means to leapfrog the lag that has been developed against India in technology, especially in the field of AI. Any further delay or negligence in this field shall have devastating repercussions, resulting in irreparable harm to Pakistan's comprehensive paradigm of security and may compromise national sovereignty. Following measures are, therefore, suggested for immediate consideration and action. It is assumed that certain steps in the same direction might already be in progress, however, these are mentioned for clarity in progression of processes:

1. An AI policy and strategy may be developed under the direct guidance of respective Gen/Flag/Air Staff, focusing on R&D, organisational integration, and regular employment of AI in all services/branches of Armed Forces. Additionally, consideration of factors like ethics, morality, humanitarian considerations etc. may also be the responsibility of this forum, as these realms of AI are still open to debate and appear to remain open in the foreseeable future. All nations interpret / prescribe AI limitations in a manner commensurate to their politico-military ambitions, current potentials and achievement schematics of planned capabilities. A careful, discreet, and flexible stance would be prudent for Pakistan.

2. The Ministry of Defence (MoD) may create a tri-services apex body for deciding specific incremental goals that it wants to attain by employing AI in the entire spectrum of future conflict operations.

A Committee on AI may be established at the Joint Staff Headquarters (JSHQ), initially with the assistance from all services' C4I branches that will be responsible for developing upon the MoD guidelines, formulation, and implementation of Joint AI policy/strategy, conduct of R&D, development of joint projects as well as AI's further growth/advancement etc.

The committee may propose creation of new services' branches or directorates for employing AI applications in respective services. In this regard, some of the perceived projects may include:

- For the purpose of **Recruitment/Human Resource Induction,** an AI software could aid in gauging the calibre of applicants and accurate assessment of their fitness, qualification, suitability for a particular task/status, under required set of parameters. It could even suggest change of track of an applicant from one domain to another or change of level/scale of engagement for an applicant with higher faculties or qualifications in that specific field.
- Similarly, in the realm of **Career Planning**, an AI programme could monitor the career and professional performance of a service person and point towards under/low performing personnel. The AI system, through synthesis of all available induction data, initial training, previous/current personal performance records, academic and behavioural data, may be able to pinpoint the broad/specific reasons behind the underperformance and also suggest measures to improve his/her performance in the current stream. It may also suggest transfer to a branch that is better suited to his/her potentials/interests.
- In **Training Processes**, simulators equipped with AI technologies for professional training will not only enhance professional skills by providing immersive technology but also reduce the cost of training by employing the most difficult of combat training exercises in an accident-free, non-threatening atmosphere. AI can also be used by commanders at different levels, for data processing and instant analysis of ongoing exercises, thereby reducing the time and allowing the decision-maker to make apt decision while staying within constricted training regime / timeline.
- In overall **Medical Application**, AI is being used in monitoring the state of military personnel during training to improve the trainee's cognitive and physical performance. Likewise, using previous cases / trends in medical/psychological ailments during peace and war, experienced by soldiers may be converted into big data and applied in an AI programme for prevention and/or early diagnostic of conditions, onset or spread of any physical or psychological ailment. Besides, an AI software handling medical stores' management can be developed in which data about all the medicines available in different military hospitals can be fed. The software would observe, catalogue and 'data-lyse' the number of regular / infrequent patients, rate of consumption of medicines / essential supplies, market availability, equipment non-availability etc. It would then coordinate the logistics systems / designated vendor for timely procurement/repair/replenish if the hospital is short on equipment/supplies.
- Incorporating AI into the **Engineering Processes** can multiply its efficiency

beyond known bounds. An AI system can monitor the workflow at units and back shops, and help engineers find quick solutions to problems by recommending procedures to timely fix a fault. The system can aid maintenance managers to accurately predict and plan scheduled/ unscheduled maintenance. AI can interpret and organise data, generating real-time reports on unethical trends, procedural weaknesses, potential failures, impending maintenance adversities, and proposing possible alternate processes and timelines for repairs. The system may also track the consumption of parts, requirements of spares and generate a forecast that caters for delivery period, thus, addressing availability issues.

3. In order to realise the above, Armed Forces need to build AI qualified Human Resource (HR) as well as infrastructure at the most urgent pace as well as:

- training the existing related technical manpower (officers/men) in AI,
- recruiting AI professionals from civil by providing non-traditional career opportunities with certain rules relaxation and attractive pay packages, and/ or,
- adopting an appropriate mix of both the above measures.

4. Academia may be regularly engaged in assisting Armed Forces in training and R&D for specific projects. For this purpose, Memorandum of Understanding (MoU) can be signed with academic institutions / individual scientists for specific projects. Similarly, AI courses at all Armed Forces' supported institutions (NUST, FAST, Bahria, Air University etc.) may be introduced to train the existing as well as the future workforce of Armed Forces.

5. The nation can also not solely rely on imported hardware in the times to come, therefore, the foundation of indigenisation of AI hardware needs to be laid now to reap benefits in the future. Therefore, existing capabilities of scientific elements of set-ups like the Strategic Plans Division (SPD) need to be enhanced towards production of high-end computing hardware, required for assimilation of AI in Pakistan. As a foreseeable future project, the developing Aviation City may also be designated with an area for AI labs, where an entire space is lined up for AI, Cyber, Robotics, Nano-tech R&D work for the aerospace industry.

6. Private / commercial entities working in the field of AI in Pakistan may be engaged through Public-Private Partnership (PPP) as they have access to global commercially available technologies and other open platforms. These expertise/ access of private organisations can be used to enhance the scope and proficiency by integrating commercially available AI solutions in the military environment.

Academia and the private sector may express genuine concerns regarding disastrous effects of military AI applications and risks to human life, for which these entities may be made partners in projects and assured of transparency and ethical employment. This could be military's mitigating procedure for ensuring a check on alleviating honest civilian concerns and maintaining mutual trust. The concept of man in/on/above/around the loop may always be ensured.

Conclusion

The world is embarking upon changed character and nature of war, at least for technically advanced countries. But it is bound to affect South Asia due to the hegemonic designs of Pakistan's eastern neighbour or in scenarios of regional instability involving global players. The threat of military AI weapons is real and present, the only uncertainty is 'When'. It is imperative for all leaders/commanders to prepare to fight and win in any future conflict that would certainly involve lethal/non-lethal AI military applications. The end objectives of all this preparation may, therefore, be to:

- Ensure timely preparedness in the new domain of AI.
- Create and improve response capacities and options in lethal/non-lethal military AI application scenarios.
- Improve performance efficiency of a lean but technologically enabled force, with AI furnished airborne / ground systems and weapons, trained in use of AI operated machines.
- Innovate and apply intelligent solutions to bring a quick end to war.
- Reduce financial burden through use of low-cost intelligent systems, training, and earliest favourable culmination of conflict.

In any future conflict, AI shall be there. The sole responsibility to face, manage and end any conflict linked to it would lie with the Armed Forces that have better training, access, and capacity to apply military AI systems.

The scenario in any immediate regional conflagration may not be as technologically advanced as being predicted by some Western research yet, against a much larger and multifaceted threat, Pakistani military needs to be ready and prepared not only to face the adversary but also surprise her with competence in innovative and advanced technologies. It is always better to have the capability and then decide to use it or not, rather than not have it at all and be at the receiving end of the enemy.

CONCLUSION

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Artificial Intelligence (AI) has been labelled as one of the most remarkable developments of the 21st Century. It is also one of the most misunderstood phenomena of modern times, with proponents and adversaries immensely divergent in their definitions of AI, its achievements, limitations, future prospects and timeframes. Despite divergences, AI algorithms are rapidly transforming the traditional working and business models of the world in almost every domain. Coupled with functioning of Internet of Things (IoT), AI has created an 'App world' providing solutions to daily life requirements of communication, transportation, business, socialising engineering, medicine, and agriculture etc. through application of media and/or medium of networks, connecting people across continents and increasing interdependence. AI applications in Medicare, Fintech, robotics, Unmanned Aerial Systems (UASs) etc. have enhanced efficiency and completely changed the rules of business in the commercial world. This AI revolution and the rate of societal change is overwhelming and inexorable. As education and connectivity spreads to the developing world, AI technologies will transform modern living and positively affect people across the globe.

The promising potential of AI has also given rise to serious competition for control of technologies and tech-denial strategies between superpowers, with China and the US locking horns in an intense trade and technology war.

Behind the US-Sino rivalry lies the battle for control of data; the core foundation of AI development and success, that profoundly affects the vast business potential of cellular and AI technologies.

In a networked world, with over 13 billion mobile devices sharing data, the urge for information and data control, utility and manipulation is irresistible. The Huawei 5G war is only the tip of the iceberg in a multibillion-dollar business for control of the world's operating systems and data.

Both China and the US have adopted different approaches to AI development. The US effort is spearheaded by a burgeoning private sector, led by tech giants such as Google, Microsoft, Apple, Intel, IBM etc.

This is supported by a top-class multinational HR talent that is attracted to the US because of her lucrative policies, luxurious lifestyle and hefty pay packages. The brain drain of world AI experts to the Silicon Valley as well as generous prospects of promising start-ups has been a mammoth challenge for native developing

countries. Nevertheless, it is this aspect of quality experts that has become a major factor in the US' leadership in the AI field.

Though in a close lag, the Chinese AI industry is catching up fast with full support of the Chinese government.

The Chinese tech rise over the last decade has been impressive and companies such as Huawei have warmed up international competition. It is quite probable that the AI world splits into the Global West with the US, its allies and some countries dividing against China leading the Global South along with her allies.

While such a split would seriously dent the globalisation effort, it may be inevitable, as the US is not likely to accept nor succumb to the notion of Chinese leading the AI market. The US would also not be able to beat the modest price tag of Chinese services. As an example, Huawei generated USD 107 billion in revenue in 2018, selling equipment to customers in 170 countries and regions around the world. Therefore, China has started to lead AI innovation and has distinctively impacted African, South American, and most Asian markets.

Due to its widespread use in most aspects of daily life, the AI development drive is being led by rapid innovations in the private sector. The commercial R&D sector, with billions invested in new programmes, is emerging at a faster pace. Self-driving cars, robots and UASs are a few fields, extensively utilising AI applications.

The use of AI in aerospace domains, especially in large and complex numeric computations, structural estimates, propulsion analysis, electro-magnetic evaluations, evaluations confirmation etc. have particularly been successful. The same civilian technologies are subsequently used for military applications with suitable modifications. This has given rise to the joint civil-military development models for creating innovative military solutions in collaboration with military industrial complexes and armed forces.

The military, while dealing in AI, is increasingly outsourcing systems development to civilian AI expert companies. Consequently, almost all US tech giants are involved with the government to aid development of systems for national security.

This aspect of civil AI industry aiding military AI development also means the opening of traditionally closed military systems of the developing world and modifying force structures, to accommodate

civil AI experts and systems for training, upgrade, maintenance and in some cases operating AI embedded unmanned systems.

As with other emerging technologies, the dual-use nature of AI applications presents exciting prospects as well as challenges for humanity. Many AI algorithms for civil use could be equally applicable to military use. Significantly, despite its many virtues, AI's dependence on data and its vulnerability to data manipulation, bias, cyber-attacks and a host of other challenges, points towards the dangerous disruptive potential of the technology and its grave implications for national security. In addition, lack of oversight and control over AI development processes entail possibilities of AI proliferation at all levels. With coding becoming a subject at primary school level in many European countries, every teenager would be able to write algorithms and put them on the net for the world to utilise. Offenders and non-state actors with malafide intent would be untraceable and hard to apprehend. The 'WannaCry' ransomware attack in May 2017 which caused a worldwide loss of USD 4 billion, hit around 230,000 computers using Microsoft Windows in 150 countries. For a world divided even on climate change, it has almost been impossible to build consensus on cyber control laws, control of disruptive technologies, AI, or LAWS etc. Not surprisingly, prime objections have been from global technology leaders who have remained ambiguous in their stance at the United Nations (UN).

Governments and international organisations have still not agreed on who should be allowed to use autonomous cyber programmes, and for what purposes, and under what conditions etc. The future would see similar trends shaping AI development (and warfare), making it difficult to control proliferation of lethal or disruptive technologies.

Historically, the ability to adapt technological revolutions to warfighting has led to fundamental changes in conduct and weaponry for warfare.

Autonomous weapons and AI represent innovative technologies for use in the battlefield, offering diverse opportunities for deterring and countering emerging threats, addressing security challenges, and advancing national interests.

AI characteristics such as data processing, accuracy, integration ease, communication, information control etc., and cyber space operations are affecting the conduct of modern warfare. AI offers militaries a transformation in training methodologies, decision assisting mechanisms, comprehensive assistance in Command and Control (C2) and an array of autonomous systems for employing a whole range of LAWS. This scenario includes the concept of hyper war - fast

paced largely autonomous systems fighting wars at the behest of humans or hybrid warfare, utilising various disruptive techniques over extended periods to significantly weaken adversaries, through clandestine or anonymous operations. The hyper war scenario points to a slow and steady shift of authority from humans to algorithms. The nuclear domain is equally affected by AI as the OODA decision loop is shortened to enhance deterrence, as more information becomes available. Alarmingly, such capabilities may also end up prompting contesting states to initiate aggression on confidence of success of first strike. The aspect of AI incorporation in nuclear C2 is also fraught with danger due to the potential for unconventional (cyber) attacks.

The most transformative change envisaged by AI champions, however, is in the aerial warfare; where AI controlled unmanned systems have been in use for the last few decades.

Future air war would see significant employment of UASs in all aerial conflict realms operating in autonomous swarm, loyal wingman, and semi-autonomous modes. The AI-UAS transformation also affects land and naval warfare with increased use of robots and tactical UASs in the army and unmanned surface and subsurface vessels in the navy.

Notwithstanding its core attributes applicable for employment in warfare, it is essential to understand that AI primarily is an enabler. On the one hand, it affects the OODA loop by making warfighting efficient and complementing Autonomous Weapon System (AWS) capabilities, while on the other side (in disruptive mode), causes widespread disorder and serious governance, social, and economic chaos. Besides, while AI is the central driving core in military technologies, it can yet not substitute hardware, weaponry, munitions etc.

While AI algorithms will make IoT, block chain and design processesof the Fourth Industrial Revolution (4IR) much more efficient. AI will, nevertheless, remain dependent on accuracy and volume of data, proficiency of the programmer, and processor's computing capacity and efficiency.

Similarly, while AI-enabled technologies will be able to gather, evaluate, and distribute large amounts of data, they will remain vulnerable to ancient practices of denial, deception, and concealment. It is also a consideration that the chaos, fog, friction, and probabilities in war will remain challenging for deciphering tools, regardless of upcoming technologies.

The concept of AI dominated warfare has different connotations for the advanced and developing countries. Most developed countries have well established and mature AI ecosystems, with their military hardware made indigenously or acquired from friendly countries. In-country Original Equipment Manufacturers (OEMs) facilitate integration and interoperability, thus ensuring optimum utilisation of weapon systems. In the near future, indigenous data cloud systems such as the US' Joint Enterprise Defence Infrastructure (JEDI) will become a key factor for security of data and control of AI assets.

Nevertheless, for the developing countries, which operate systems of different origins and do not have an established AI enabling environment, it would be very difficult to integrate AI assets without compromising data security and system performance.

Traditionally, the package of high-tech exports, including Technical Support Teams (TSTs) of OEMs, who remain present on site to look after unforeseen impediments and glitches; also take care of technology proliferation concerns. The periodic requirements of system maintenance and upgradation would also add to the financial cost of AI equipment/applications. Furthermore, the military forces of these countries employ weapon systems of different makes and vintages. As it would be difficult to phase out existing equipment prematurely, these forces would be compelled to operate a mix of old hardware with newer AI systems, which may not become a fully integrated battle-fighting system. It is also utterly impractical for the developing world to remain aloof of global developments in AI, especially when it is not only being used for national development but also for establishing a comprehensive security paradigm.

As a first step, an AI awareness and education policy should be implemented to understand and pursue technological development with an ultimate aim to gain indigenous autonomy in the field. Without essential hard/software controls, it would not be possible to create secure domestic AI systems for Pakistan's national security.

The disparity in AI capability is also leading to different forms of war strategies, i.e., AI versus AI and AI versus non-AI adversaries. The contours of AI versus AI are already visible in hybrid techniques between the US, China, and Russia, in their contemporary employment of info warfare and cyber-attacks. The sequence of future hostilities could, thus, be marked by the onslaught of cyber-attacks, preceding any kinetic application through UCAVs, robots, and swarms. Secure in remote continental America, the US has traditionally relied heavily on power projection through military bases on foreign lands, naval armadas, long-range ballistic/cruise

missiles, and strategic UAVs such as the Global Hawk etc. Except for 9/11, the American homeland had never experienced the ravages and destruction of war. However, with the advent of AI dominated cyber-attacks, on-land/anti-carrier swarming, subsurface unmanned autonomous systems and hypersonic weapons, this notion of invincibility may be changing. Anti-satellite weapons and space-based cyber warfare is already a strategy to sever control of worldwide networked AI systems.

Strategies and weapons using laser, EM spectrum disruption, directed energy systems etc., to counter unmanned aerial, land and sea systems are already undergoing testing/trial stage. The anti-AI weapon systems would rely heavily on targeting control networks, data flow and power systems, for converting soft kill gains to hard kill destruction.

The best example of AI versus non-AI employment can be seen in Israeli strategies employed against the Palestinians. Data from the entire Palestinian territories is collected, monitored, analysed, and utilised to direct unmanned and manned systems for accurate employment of their weapons. Stripped of any lethal weapons or matching AI/Cyber capability, the Palestinians respond though conventional weapon fire and rockets, which neither emit data nor are cyber controlled.

The data acquisition challenge has also given rise to new academic branches of data sciences, such as data engineering, data mining, cloud computing, data analytics etc. In the future, it would be difficult to venture into the AI field without availability of the requisite expertise in these domains.

Pakistan faces numerous challenges, as it is in the process of taking initial steps towards establishing an AI ecosystem. The potential AI related talent in university graduates from computer and IT related fields needs to be harnessed. The syllabi in educational systems needs to be updated. Pakistan's gifted start-ups solicit human as well as financial support.

The industrial sector requires revamped and better planning to benefit from the latest trends in AI. Traditional governance must move on to e-governance and the indigenous computer hardware industry requires revival. Pakistan also needs to take serious steps towards data security and indigenising AI capability.

Entire national efforts to develop an indigenous cyber security system must be synergised. With initial steps taken, Pakistan must move on towards establishing its own AI data and storage systems. In the future, this may become the only

option for secure AI operations. The Armed Forces have to remain in step, in enhancing efforts to educate their respective force on AI fundamentals, limitations, developments, military applications etc. and guard against the risk of complacency. Only a force with an intellectual edge will derive the most out of AI systems. The induction of AI systems has to be strictly evaluated in requisites of operational capability, safety, security, adaptability, vulnerability, and control of technologies.

Pakistan as the sole Muslim nuclear power faces a myriad of security challenges. It is already a consistent target of multitude of coercive strategies. Consequently, it would be difficult to win over new friends in the AI and data business. Quest for indigenous AI systems development, therefore, may be the only plausible solution. In the future, AI asymmetry would be the ultimate and conclusive winning recipe.

While predicting the future of AI, the current times can be described as the 'AI Spring', with global trends advancing towards projected AI capabilities. However, the question of how long it will take for AI to have a fully intelligent human-like intelligence system, has divided the AI specialist community. While some proponents and industrial pundits point to tremendous contemporary strides with high hopes of realising near human intelligence in a few decades; conservatives estimate such capability in a distant future. Numerous studies also point to the emerging challenges in computational and processing powers, and the size of transistors, which cannot be reduced further. Besides, the free data storage aspect is also set to face difficulties, as data generation is fast exceeding storage capacities.

Similarly, for AI to be successfully applied to military applications, it needs to meet stringent safety, reliability, and security conditionalities. At present, defence-related AI technology is under maturing arrangements and needs to be perfected before induction in the war zone.

Historically, technological edge is of little value unless it is supplemented with a compatible enabling environment. Currently, AI compatible ecosystems and intellectually equivalent human resource is only available with a select few. For the rest, it would be prudent to learn how best combined human cognition functions with available AI resources can perform for the benefit of the entire human race. As AI augments existence, compatibility, and survival skills, and impacts the world, it is wise to be a part of this ultimate life altering transformation rather than becoming a passive object in this change.

ANNEXURE

List of Abbreviations

ADAS	Advanced Driver Assistance Systems
AI	Artificial Intelligence
ARF	Advanced Research Foundation
ATC	Air Traffic Control
ATS	Air Traffic Services
AWS	Autonomous Weapon System
BRAIN	Brain Research through Advancing Innovative Neuro-technologies
CASE	Centre for Advanced Studies in Engineering
CENTAIC	Centre of Artificial Intelligence and Computing
CIMON	Crew Interactive Mobile companion
CPEC	China-Pakistan Economic Corridor
C2	Command and Control
C4I	Command, Control, Communications, Computers, Intelligence
DARPA	Defence Advanced Research Projects Agency
DoD	Department of Defense
Dstl	Defence Science and Technology Laboratory
EBO	Effect Based Operations
ECUs	Engine Control Units
4IR	Fourth Industrial Revolution
FAST	Foundation for Advancement of Science and Technology
GoP	Government of Pakistan
HEC	Higher Education Commission
HEIs	Higher Education Institutions
HMI	Human-Machine-Interfaces
HR	Human Resource
IBA	Institute of Business Administration
IDF	Israeli Defence Forces
IoT	Internet of Things

JEDI	Joint Enterprise Defence Infrastructure
JSHQ	Joint Staff Headquarters
JV	Joint Ventures
LAWS	Lethal Autonomous Weapon Systems
LM	Loitering Munition
MALE	Medium-Altitude Long-Endurance
MCF	Military-Civil Fusion
MoD	Ministry of Defence
MoU	Memorandum of Understanding
NAIP	National AI Policy
NCAI	National Centre for Artificial Intelligence
NED	Nadirshaw Eduljee Dinshaw (University)
NUST	National University of Sciences and Technology
NUCES	National University of Computer and Emerging Sciences
OEMs	Original Equipment Manufacturers
OODA	Observe-Orient-Decide-Act
PAF	Pakistan Air Force
PIAIC	President's Initiative for Artificial Intelligence and Computing
PPP	Public-Private Partnership
R&D	Research & Development
RCAI	Research Centre for Artificial Intelligence
RFARP	Russian Foundation for Advance Research Projects
SPD	Strategic Plans Division
ToTs	Transfer of Technologies
TSTs	Technical Support Teams
UN	United Nations
UAS	Unmanned Aerial Systems
UAVs	Unmanned Aerial Vehicles
UCAV	Unmanned Combat Aerial Vehicle
UET	University of Engineering and Technology

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