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ICT Trends

Digital Healthcare | Mobile Payment | Assistive Technologies | Internet of Things (IoT)

5th Generation Mobile Networks (5G) | Artificial Intelligence and Machine Learning

Blockchain and Shared Ledgers | 3D Printing

ICT Trends Artificial Intelligence & Machine Learning

APCICT
ASIAN AND PACIFIC TRAINING CENTRE FOR INFORMATION AND COMMUNICATION TECHNOLOGY FOR DEVELOPMENT

ICT Trends

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ABOUT

The 2030 Agenda for Sustainable Development provides a plan of action for achieving an economically, socially and environmentally sustainable future. Information and communication technologies (ICTs) are recognized as enablers of the 2030 Agenda for Sustainable Development. Their diffusion and application in all sectors of society provide new solutions to persistent development challenges.

As new technologies, along with increased connectivity, spread rapidly and transform the ICT landscape around the world, it is important for policymakers and government officials to understand the current trends in order to fully leverage the potential benefits of ICT.

This publication aims to provide timely and relevant information on the major ICT trends and the implications of these trends. It serves as a knowledge resource for policymakers and government officials in Asia and the Pacific to increase their awareness and appreciation for the continuously evolving ICT landscape. It intends to present a broad understanding of how new and emerging ICT trends could be utilized to support sustainable and inclusive development.

This publication is a collection of brief write-ups on the following eight ICT trends:

1. Digital Healthcare
2. Mobile Payments
3. Assistive Technologies
4. Internet of Things
5. 5th Generation Mobile Networks
6. Artificial Intelligence and Machine Learning
7. Blockchain and Shared Ledgers
8. 3D Printing

This set of topics was selected based on their relevance to achieving the Sustainable Development Goals (SDGs). The topics selected also aim to provide a broadly representative sample covering a wide range of technology areas spanning hardware, networking, software and data, as well as application domains (i.e., healthcare, finance and disability).

Each write-up introduces the topic by first describing the technology features and components, and then proceeds to highlight potential application areas and use cases, with examples from the Asia-Pacific region and beyond. This is followed by a discussion on the policy implications involving regulatory aspects, standards and linkages to the SDGs. Each write-up may vary slightly to highlight relevant aspects.

The write-ups can be read independent of the other. Although the topics have been presented in a certain sequence, readers may start with any topic of interest and move on to any other topic that they find of relevance or interest. While going through the write-ups, readers may find multiple connections across application domains and technology areas. This has been intentional to foster a better appreciation of the potential use of the new and emerging technologies for sustainable development. As these are brief descriptions, interested readers are advised to go through the references provided at the end of the write-ups for a more comprehensive understanding of the topics.

ACKNOWLEDGEMENTS

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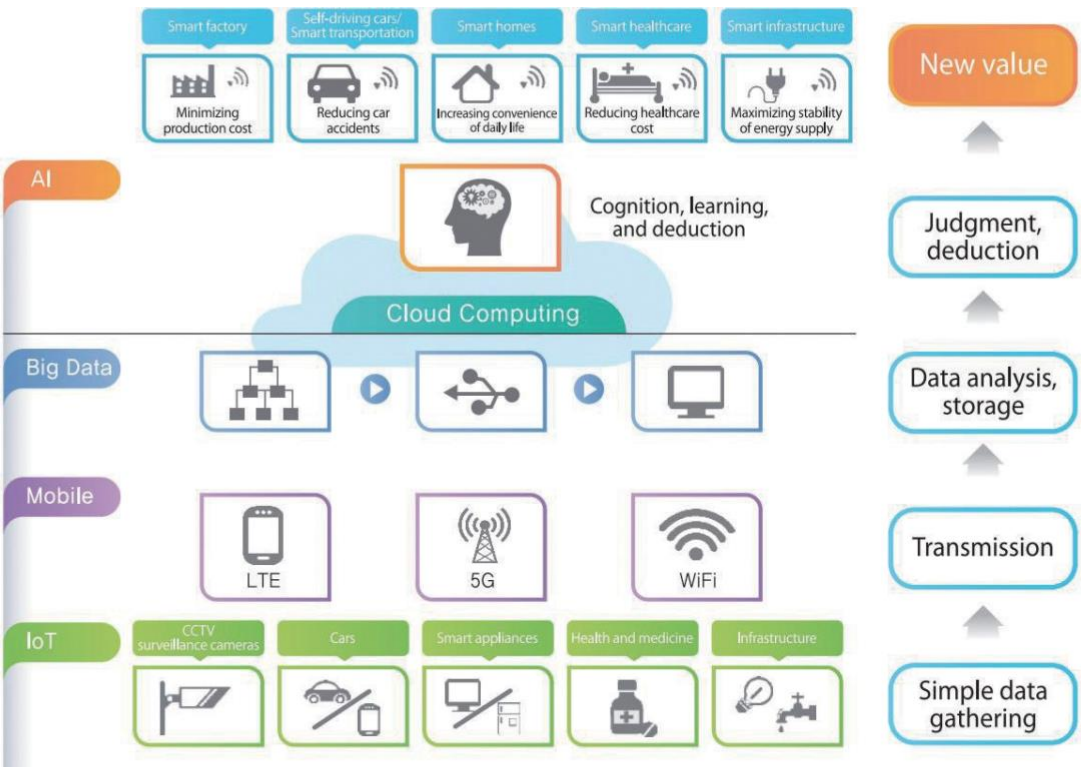
1. Introduction

The essence of intelligence is learning. Just as humans learn how to communicate, identify visual patterns or drive a car, efforts are underway to train machines to perform such tasks based on powerful learning algorithms. A common method of training machines consists of providing them with labelled data, e.g., photographs of cats combined with the word "cat" as a label. Such machines are then said to possess artificial intelligence (AI) if they can, given their training, ascribe the correct label to a previously unknown data set with sufficient accuracy. Following the previous example, a machine would then be able to identify a cat in an unfamiliar photograph.

Typical applications of AI include autonomous driving, computer vision, decision-making and natural language processing (NLP). AI holds the benefit of being adaptable to very heterogeneous contexts just like humans. Well-trained AI is capable of performing certain tasks at the same skill level as humans but with the additional advantages of high scalability, error-free operations and continuity. AI can discover patterns in the data that are too complex for human experts to recognize. In some specific applications such as computer vision, AI has already achieved performance levels surpassing that of humans (e.g., in skin cancer diagnostics and finger print analysis). Some potential application areas of AI and their linkages to other emerging information and communication technologies (ICTs) are given in Figure 1.

Figure 1: AI and the Emerging ICT Landscape



The idea of AI dates back to the 1950s when AI successes were largely limited to the scientific field. In the last few years, the gap has been bridged between science and business applications. Their usage is fuelled by the abundance of data, algorithmic advances and the application of high-performance hardware for parallel processing.

In the industrial sector, AI application is supported by the increasing adoption of devices and sensors connected through the Internet of Things (IoT),[1] production machines, autonomous vehicles[2] and devices carried by humans, which generate enormous amounts of data.

Among the many branches and connections feeding into AI, machine learning (ML) is the dominant methodology or major component of implementing AI. ML is an approach to creating AI and is focused on developing intelligent systems without the need to explicitly define rules that determine behaviour. ML allows a system to evolve with changing environmental conditions and this is critical for a system or service to move from the state of being managed to one of being optimized.

As most AI systems today are based on ML, both terms are often used interchangeably. In this report, both terms will also be used interchangeably.

According to Tractica, the global AI software industry will grow from USD 1.4 billion in 2016 to USD 59.8 billion by 2025.[3] Many enterprises are working on different areas of AI and approaching it from very contrasting dimensions. IBM has pledged to invest USD 3 billion to make its Watson cognitive computing service a force in the IoT. Baidu, the Chinese Internet giant announced in September 2017 that their Apollo Fund would invest CNY 10 billion (USD 1.5 billion) in over 100 autonomous driving projects over the next three years.[4]

AI is expected to enable the automation of knowledge work, or tasks that require judgement or creative problem solving.[5] AI-based solutions can potentially increase productivity by 40-50 per cent for 290 million knowledge workers globally by 2025, generating a USD 5.2 trillion-6.7 trillion economic impact annually, of which USD 4.3 trillion-5.6 trillion will be felt in developed markets, where increases in automation could drive additional productivity equivalent to 75 million-90 million full-time workers.

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1 IoT is a system of interrelated computing devices, mechanical and digital machines, objects, animals or people that are provided with unique identifiers and the ability to transfer data over a network without requiring human-to-human or human-to-computer interaction. IoT has evolved from the convergence of wireless technologies, micro-electromechanical systems and the Internet.

2 An autonomous vehicle, also called driverless car, self-driving car or automated car, is a robotic vehicle that is designed to travel between destinations without a human operator.

3 Tractica, "Artificial Intelligence Software Revenue to Reach $59.8 Billion Worldwide by 2025", 2 May 2017. Available from https://www.tractica.com/newsroom/press-releases/artificial-intelligence-software-revenue-to-reach-59-8-billion-worldwide-by-2025/.

4 Baidu, "Baidu Announces Apollo 1.5 and a 10 Billion yuan Autonomous Driving Fund", 21 September 2017. Available from http://globenewswire.com/news-release/2017/09/21/1125651/0/en/Baidu-Announces-Apollo-1-5-and-a-10-Billion-yuan-Autonomous-Driving-Fund.html.

5 Jaques Bughin and others, "Artificial intelligence: The Next Digital Frontier?" McKinsey Global Institute Discussion Paper, June 2017. Available from https://www.mckinsey.de/files/170620_studie_ai.pdf.

2. Technology

AI is intelligence exhibited by machines, with machines mimicking functions typically associated with human cognition. AI functions include all aspects of perception, learning, knowledge representation, reasoning, planning and decision-making. The ability of these functions to adapt to new contexts, i.e., situations that an AI system was not previously trained to deal with, is one aspect that differentiates an AI from any other piece of software code.

History & Evolution of AI

The idea of computer-based artificial intelligence dates to 1950, when Alan Turing proposed what has come to be called the Turing test: can a computer communicate well enough to persuade a human that it, too, is human? A few months later, Princeton students built the first artificial neural network, using 300 vacuum tubes and a war surplus gyropilot.

The term “artificial intelligence” was coined in 1955, to describe the first academic conference on the subject, at Dartmouth College. That same year, researchers at the Carnegie Institute of Technology (now Carnegie Mellon University) produced the first AI program, Logic Theorist. Advances followed often through the 1950s: Marvin Lee Minsky founded the Artificial Intelligence Laboratoryat MIT, while others worked on semantic networks for machine translation at Cambridge and self-learning software at IBM.

Funding slumped in the 1970s as there were no visible practical applications for AI.

University researchers’ development of “expert systems”—software programs that assess a set of facts using a database of expert knowledge and then offer solutions to problems—revived AI in the 1980s only to slump again due to unviable applications.

Interest in AI boomed again in the 21st century as advances in fields such as deep learning, underpinned by faster computers and more data, convinced investors and researchers that it was practical and profitable to put AI to work. To come to age AI needed killer applications, high speed communications and computing which has finally come together in the beginning of 21st Century.

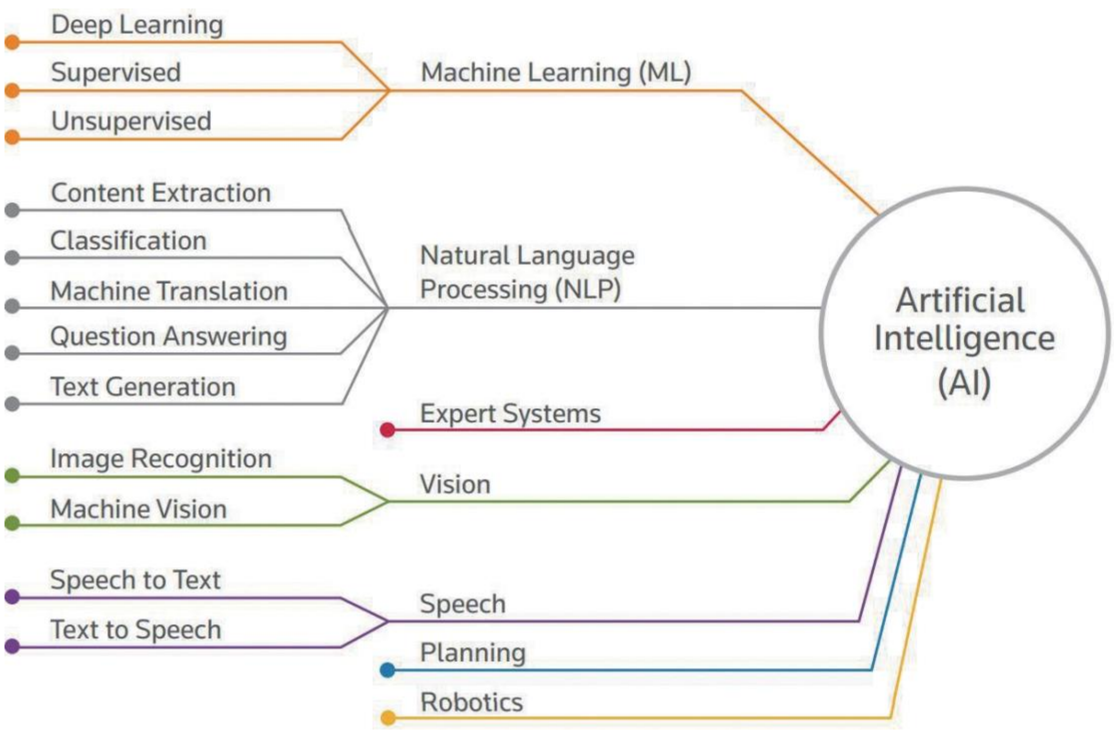
Source: Bughin, J, Hazan, E & et al, 2017, Discussion Paper, Artificial Intelligence the next digital frontier? Mckinsey Global Institute

Source: Jaques Bughin and others, “Artificial intelligence: The Next Digital Frontier?” McKinsey Global Institute Discussion Paper, June 2017. Available from https://www.mckinsey.de/files/170620_studie_ai.pdf.

2.1 AI Ecosystem

AI has many branches with many significant connections and commonalities among them that make up for the whole ecosystem. The most active ones are shown in Figure 2.

Figure 2: Branches of AI



Source: Michael Mills, “Artificial Intelligence in Law: The State of Play”, *Thomson Reuters Legal Research Institute*, 2016.

As ML and NLP are the two most important areas of applications in the AI ecosystem, the report dwells deeper into these areas.

2.2 Machine Learning

ML uses a learning and refinement process to modify a model of the world. The objective of the process is to optimize an algorithm's performance on a specific task so that the machine gains a new capability. Typically, large amounts of data are involved. The process of making use of this new capability is called inference. The learned ML algorithm predicts properties of previously unseen data.

There are three main types of learning within ML, namely supervised learning, reinforcement learning and unsupervised learning. They differ in how feedback is provided. Supervised learning uses labelled data ("correct answer is given") while unsupervised learning uses unlabelled data ("no answer is given"). In reinforcement learning, feedback includes how good the output was but not what the best output would have been. In practice, this often means that an agent continuously attempts to maximize a reward based on its interaction with its environment.

Since the late 2000s, deep learning has been the most successful approach to many areas where ML is applied. It can be applied to all three types of learning mentioned above. Neural networks with many layers of nodes and large amounts of data are the basis of deep learning. Each added layer represents knowledge or concepts at a level of abstraction that is higher than that of the previous one. Deep learning works well for many pattern recognition tasks without alterations of the algorithms as long as enough learning data is available.

2.3 Natural Language Processing

NLP is a field of computer science, AI and computational linguistics concerned with the interactions between computers and human (natural) languages, and, in particular, concerned with programming computers to fruitfully process large body of natural language. Challenges in NLP frequently involve natural language understanding, natural language generation (frequently from formal, machine-readable logical forms), connecting language and machine perception, dialog systems, or some combination thereof.

The development of NLP applications is challenging because computers traditionally require humans to "speak" to them through a limited number of clearly enunciated voice commands or by using a programming language that is precise, unambiguous and highly structured. Human speech, however, is not always precise—it is often ambiguous and the linguistic structure can depend on many complex variables, including slangs, dialects and social contexts. The ultimate goal of NLP is to build conversational interfaces that handle interactions between machines and humans in the preferred language of the human.

Current approaches to NLP use ML to analyse patterns in data and continually improve the program's own understanding. Much of the research being done on NLP today revolves around search and chatbots.[6]

Common NLP tasks in AI software programs today include:

- Automatic speech recognition – Converts audio signals to text;
- Part-of-speech tagging and parsing – Divides written text and spoken words into meaningful units;
- Machine translation – Translates one human language to another;
- Natural language understanding – Analyses text to extract meta-data about sentiment and speaker intent;
- Co-reference resolution – Identifies mentions that refer to the same entity.
- Deep analytics – Applies sophisticated data processing techniques to gather information from unstructured and semi-structured data; and
- Named entity extraction – Finds and classifies names of people, companies, countries and other pre-classified categories in text and spoken word.

6 A chat robot (chatbot for short) is designed to simulate a conversation with human users by communicating through text chats, voice commands or both.

3. Applications and Use Cases

AI as an idea is very old, was always in the realm of science fiction, and touted to have surfaced as soon as digital computing became a reality. Every time an AI or ML system appeared on the horizon, it was renamed and moved away from the domain of AI. John McCarthy, an American computer scientist and cognitive scientist, considered the founder of the discipline of AI once remarked, "as soon as it works, no one calls it AI anymore". Examples of AI technologies that are used in daily life are shown in Table 1.

Table 1: Examples of AI in Daily Life

Area	Examples of Use
Expert Systems	Flight tracking systems
Natural Language Processing	Google Now feature, search engines, Apple's SIRI – digital assistant, speech recognition
Neural Networks	Pattern recognition systems such as face recognition, character and handwriting recognition
Robotics	Industrial robots
Fuzzy Logic	Consumer electronics appliances

Source: Tutorial Points, "Artificial Intelligence Tutorial in PDF". Available from https://www.tutorialspoint.com/artificial_intelligence/artificial_intelligence_pdf_version.htm.

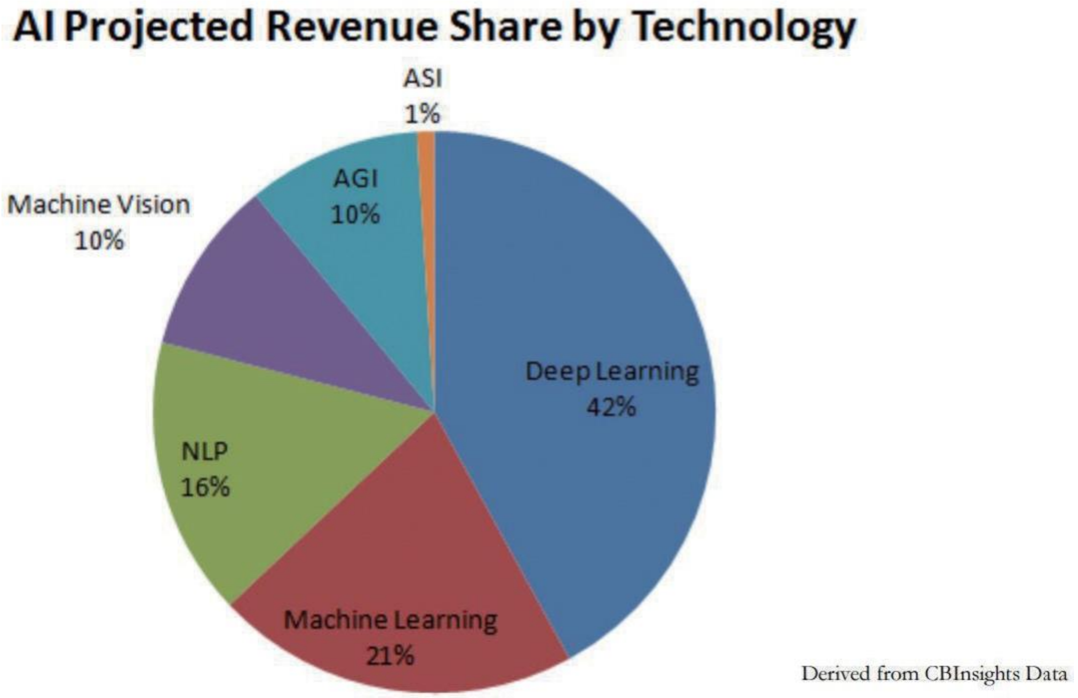
In effect, AI has not yet experienced wide-scale commercial deployment, but many technologies based on AI are in use under various nomenclatures. AI has become an essential part of the technology industry including the more than 3.5 billion Google searches made every day, and is providing solutions to many of the most challenging problems in computer science. The combination of AI, ML and natural user interfaces (such as voice recognition) is making it possible to automate many knowledge workers' tasks that were regarded as impossible or impractical for machines to perform (i.e., decision-making under uncertainty, learning, speech recognition, translation and visual perception).

Advances in AI and ML have been facilitated by the availability of large and diverse data sets, improved algorithms that find patterns in mountains of data, and powerful graphics processing units, which have brought new levels of mathematical computing power. Advances in the speed of graphics processing units have accelerated the training speed of deep learning systems by five or six-folds in the last two years.

The data that the world creates[7] every day translates into more insights and higher accuracy because it exposes algorithms to more examples they can use to identify correct and reject incorrect answers. ML systems enabled by these torrents of data have reduced computer error rates in some applications, for example in image identification, to about the same as the rate for humans.

Figure 3 shows the share of revenue in popular areas of AI usage.

Figure 3: Popular Areas of AI Usage by Revenue, 2017-2025

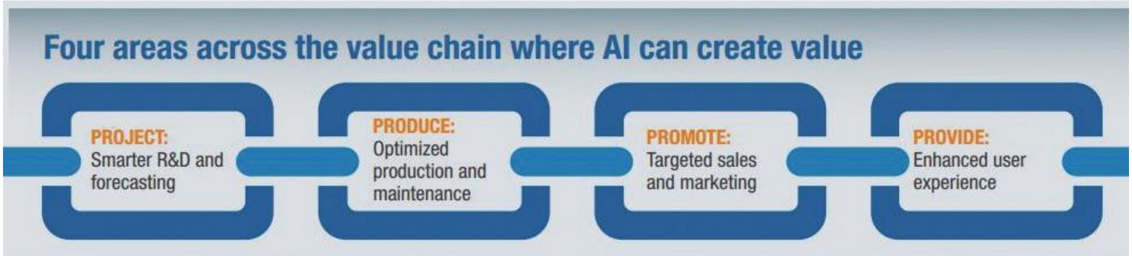


Source: Kartik Gada, "Artificial Intelligence: The Ultimate Technological Disruption Ascends", *Woodside Capital Partners*, January 2017. Available from http://www.woodsidecap.com/wp-content/uploads/2017/01/Artificial-Intelligence-Report.pdf.

AI can create value in four areas: (1) enabling companies to better project and forecast to anticipate demand, optimize research and development, and improve sourcing; (2) increasing companies' ability to produce goods and services at lower cost and higher quality; (3) helping to promote offerings at the right price, with the right message and to the right target customers; and (4) enabling rich, personal and convenient user experiences.

7 About 2.2 exabytes.

Figure 4: AI Value Chain



Source: Jaques Bughin and others, "Artificial intelligence: The Next Digital Frontier?" McKinsey Global Institute Discussion Paper, June 2017. Available from https://www.mckinsey.de/files/170620_studie_ai.pdf.

While ML can bring highly valuable benefits to all sectors, some technologies are particularly suited for business application in specific sectors, such as robotics for retail and manufacturing, computer vision for healthcare, and NLP for education. IoT is another area that is expected to involve AI in a significant manner.

3.1 Projection and Forecasting

The first area in which AI can create value is projection and forecasting. Organizations need to constantly anticipate the future to gain competitive advantage. AI allows businesses to provide better forecasts for their supply chain and design better offerings through its ability to digest disparate data, automatically adjust to new information, and discern trends and patterns that can be acted upon. This includes forecasting demand to stock only the specific quantities of specific products, and anticipating sales trends to order more soon-to-be-popular items. The benefits of projections and trending go beyond traditional business sectors—for example, by using sophisticated algorithms, health systems can increasingly predict and prevent major epidemics.

When it comes to matching supply and demand, electric utilities are a special case where real-time need exists. Making short-term load forecasts more accurate in order to adjust supply to meet anticipated demand can deliver enormous savings, reduce waste and carbon emissions, and add to system resilience. An example of this is the National Grid in the United Kingdom that is collaborating with DeepMind, an AI start up bought by Google in 2014, to predict supply and demand variations based on weather-related variables and smart meters as exogenous inputs.[8] The goal is to cut national energy use by 10 per cent and maximize the use of renewable power. AI is also used to briefly switch off air conditioning at participating businesses as it forecasts the approach of peak consumption, easing the load for all and postponing or even forgoing the need to fire up peak generating capacity.

8 Madhumita Murgia and Nathalie Thomas, "DeepMind and National Grid in AI talks to balance energy supply", *Financial Times*, 12 March 2017. Available from https://www.ft.com/content/27c8aea0-06a9-11e7-97d1-5e720a26771b.

Using AI to forecast demand allows businesses to optimize their sourcing more broadly, including fully automating purchases and order processing. Otto, a German online retailer, uses an AI application that is 90 per cent accurate in forecasting what the company will sell over the next 30 days. The forecasts are so reliable that the retailer builds inventory in anticipation of the orders that the AI application forecasts, enabling it to speed deliveries to customers and reduce returns.[9]

AI-powered technologies can help deliver more efficient designs than were previously achievable by eliminating waste in the design process. An AI start-up[10] has compressed design processes that used to take months (sometimes a year or more), to roughly four weeks, saving chipmakers the cost of iterations and testing.[11]

3.2 Production and Maintenance

The second area where AI can help create value is in product development (e.g., semiconductors, aircraft engines) and services provision (e.g., education, healthcare, energy, consumer goods distribution). In these roles, AI can replace humans through automation or complement teams of people. For example, at the warehouse of a British online supermarket where it has embedded AI and robotics at the core of its operations, robots steer thousands of product-filled bins over a maze of conveyor belts and deliver them to human packers just in time to fill shopping bags. Other robots move bags to delivery vans whose drivers are guided to customers' homes by an AI application that picks the best route based on traffic conditions and weather.[12]

Advances in computer vision are behind many developments in collaborative and context-aware robots. Enhanced vision is enabled by computers that are more powerful, new algorithmic models and large training data sets. Within the field of computer vision, object recognition and semantic segmentation (or the ability to categorize object type, such as distinguishing a tool from a component) have advanced significantly in their performance. They allow robots to behave appropriately in the context that they operate, for example by recognizing the properties of the materials and objects they interact with. They are flexible and autonomous systems that are capable of safely interacting with the real world and humans.

9 Mike Kaput, "This Ecommerce Company Uses Artificial Intelligence to Accurately Predict What You'll Buy Next", *Marketing Artificial Intelligence Institute*, 27 April 2017. Available from https://www.marketingaiinstitute.com/blog/this-ecommerce-company-uses-artificial-intelligence-to-accurately-predict-what-youll-buy-next.

10 Jaques Bughin and others, "Artificial intelligence: The Next Digital Frontier?" McKinsey Global Institute Discussion Paper, June 2017. Available from https://www.mckinsey.de/files/170620_studie_ai.pdf.

11 Ibid.

12 Rory Cellan-Jones, "Shopping robots on the march", *BBC News*, 7 February 2017. Available from http://www.bbc.com/news/technology-38892383.

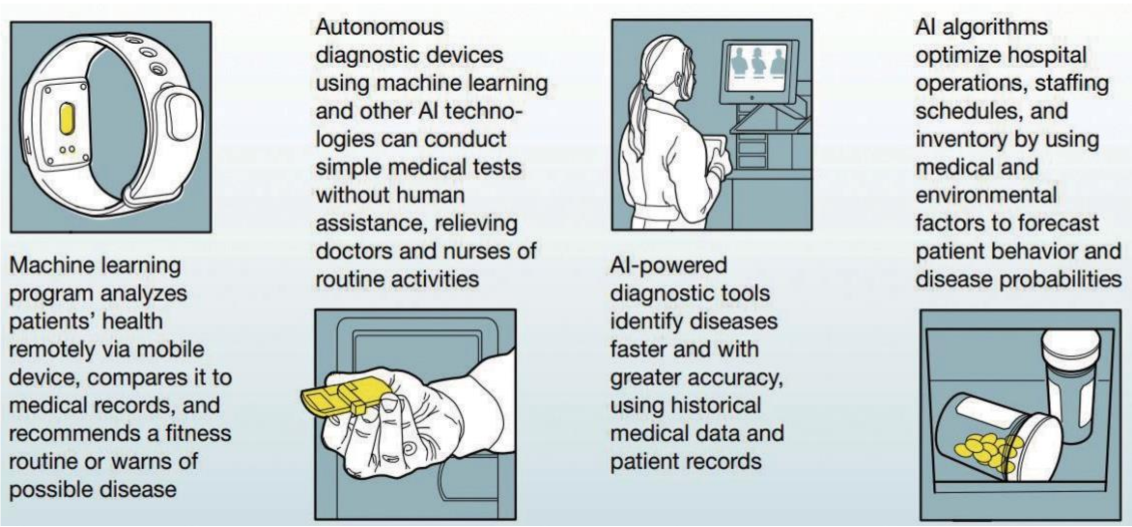
AI-enhanced, camera-equipped logistics robots can be trained to recognize empty shelf space. Deep learning can also be used to correctly identify an object and its position. This enables robots to handle objects without requiring the objects to be in fixed, predefined positions.

In addition to speeding up processes, reducing costs and increasing output, AI has the huge potential to improve quality by reducing errors. Semiconductor manufacturers are starting to use AI engines to identify root causes of yield losses[13] that can be avoided by changing production processes.

In asset-heavy businesses, keeping complex systems running with minimal downtime is another key opportunity for AI. Utility companies can shift from regularly scheduled maintenance of their extensive electrical grids to condition-based maintenance run by AI. Using data from sensors, drones and other hardware, ML applications can help grid operators avoid decommissioning assets before their useful lives have ended, while simultaneously enabling them to perform more frequent remote inspections and maintenance to keep assets working well.

AI is also enabling preventive care. Clinicians use AI to manage patients' health remotely via wearable wireless sensors, with the aim to keep them healthy, fit and out of hospitals. To do this, AI tools will take into account not only patients' medical histories and genetic makeup, but also environmental factors that can influence health, such as pollution and noise where they live and work.

Figure 5: AI in Healthcare



Source: Jaques Bughin and others, "Artificial intelligence: The Next Digital Frontier?" McKinsey Global Institute Discussion Paper, June 2017. Available from https://www.mckinsey.de/files/170620_studie_ai.pdf.

13 Yield losses are losses incurred during manufacturing when products have to be disposed of or reworked due to defects.

3.3 Sales and Marketing

The third area where AI can create value is promotion, or marketing offerings at the right price, with the right message and to the right target audience. With big data, companies can use AI to price goods and services dynamically, raising prices when demand rises or a consumer appears willing to pay more, and lowering them when the opposite happens.

Consumers are well connected on the Internet and social media and use them to continuously redefine value by comparing prices online. The optimal price for a product depends on many factors: the day of the week, season, time of day, weather, channel and device, competitors' prices, and much more. The challenge is to set the optimal price in relation to time. The right price at the right time increases customer satisfaction and leads to more sales and higher profit. AI can determine the price elasticity for every item and automatically adjust prices according to the chosen product strategy.

AI can also help identify most valuable or profitable customers to target in marketing campaigns. The size of the discount, the merchandise on offer and other variables can be determined by an AI program that has looked for clues about what customers will like based on previous purchases, age, home address, web browsing habits and mounds of other data.

3.4 User Experience

The fourth area where AI can create value is in enhancing the user experience[14] and creating new sources of value to make it richer, more tailored and more convenient. For example, when a regular supermarket shopper puts a bunch of bananas in the cart, cameras or sensors could relay the information to an AI application that would have a good idea of what the shopper likes based on previous purchases. The app could through a video screen on the cart, suggest that bananas would be delicious with a chocolate fondue, which the purchase history suggests the shopper likes, and remind the shopper of where to find the right ingredients. Another example is an AI application from an athletic shoe company that could record and monitor a runner's exercise routine and running paths, and also recommend appropriate footwear.

Amazon has built a retail outlet in Seattle, USA, that allows shoppers to take food off the shelves and walk directly out of the store without stopping at a checkout kiosk to pay. The store, called Amazon Go, relies on computer vision to track shoppers after they swipe into the store and associate them with products taken from shelves.

14 Accenture, *Technology for People: The Era of the Intelligent Enterprise – Technology Vision 2017* (2017). Available from https://www.accenture.com/t00010101T000000Z__w__/de-de/_acnmedia/Accenture/next-gen-4/tech-vision-2017/pdf/Accenture-TV17-Full.pdf.

Delivery drones will significantly benefit from breakthroughs in deep learning, which will help them categorize and handle anomalous situations, such as when no one is home to accept a delivery.

Personalizing user experiences has huge advantages in healthcare and education. In healthcare, treatment decisions based on AI analysis of existing science, data from tests and patient monitoring with remote diagnostic devices carry the promise of significantly increased efficacy.

Several companies already use AI technologies to tailor treatments to individuals. One of the examples is Mindmaze[15] that has developed an AI application for the rehabilitation of patients who have suffered brain injuries through strokes or other incidents to retrain their bodies to work again.

Figure 6: AI for Patient Rehabilitation

Source: Sramana Mitra, "Billion Dollar Unicorns: MindMaze Channels Virtual Reality into Healing", *One Million by One Million Blog*, 8 July 2016. Available from http://www.sramanamitra.com/2016/07/08/billion-dollar-unicorns-mindmaze-channels-virtual-reality-into-healing/.

3.5 Some Use Cases

Case: Use of AI in the Banking Industry

The banking industry has been using AI to improve customers' banking experience, gain insights into customers' needs to design customer acquisition and marketing strategies, and prevent fraud.

For instance, banks are using chatbots to help with customer service inquiries. DBS Bank launched India's first mobile-only bank called, "Digibank" in 2016, which allows customers to access banking services through the Digibank mobile app or through various mobile messaging apps like Facebook Messenger. Digibank uses conversational AI technology to enable customers to use natural language while banking. For example, if customers want to check their balance in their

15 Sramana Mitra, "Billion Dollar Unicorns: MindMaze Channels Virtual Reality into Healing", *One Million by One Million Blog*, 8 July 2016. Available from http://www.sramanamitra.com/2016/07/08/billion-dollar-unicorns-mindmaze-channels-virtual-reality-into-healing/.

bank accounts, they can simply text “How much do I have?” which will be answered promptly. According to DBS, the AI-driven bot and virtual assistant handles 82 per cent of customer inquiries and requests without a live agent’s involvement in India.[16]

Another principal application of AI in the banking industry is wealth management and advisory services. The Bank of America is launching an AI bot for its smartphone app by 2018. The AI bot, “Erica”, will use AI to learn consumers’ personal spending habits and offer financial advice in response.[17]

Banks are using AI to obtain a more comprehensive and insightful understanding of customers, by introducing the automation of insights that helps to maximize the efficiency and reach of marketing programmes. The banking system has streams of data coming in from digital channels such as, customer information systems, mobile applications, websites, call centres and third-party data sources. The use of AI in analytics has enabled financial institutions to learn about individual customer needs and preferences, the kinds of tailored products and services to offer, and how best to personally engage with customers within and across the channels.[18]

Additionally, some banks have used AI to improve upon efficiency in terms of detecting fraudulent phone calls. The AI software can build an audio fingerprint of each caller based on different features of the human voice and use this to confirm each user.

Case: AI in Language Translation

Traditionally, applications of AI were focused around numeric challenges. However, recent AI applications that process text across languages are quickly changing the perspective of where AI and ML techniques can be applied to solve complex language-based problems.

AI applications are looking into behavioural models and predicting culture, as well as using speech-to-text and text-to-speech combined with advanced predictive models for a range of applications. One of the examples is using AI for machine translation. A Thailand-based technology company has developed a hybrid neural machine translation platform that can translate over 100 billion words of patent content from English into Japanese, Chinese and Korean.[19]

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16 Kasisto, "DBS leverages Kasisto's conversational AI platform to launch digibank, an entire bank in the phone, in Indonesia", *PR Newswire*, 8 September 2017. Available from https://www.prnewswire.com/news-releases/dbs-leverages-kasistos-conversational-ai-platform-to-launch-digibank-an-entire-bank-in-the-phone-in-indonesia-300516273.html; and DBS Bank, "DBS to roll out conversational banking in mobile messaging apps by year end", 17 August 2016. Available from https://www.dbs.com/newsroom/DBS_to_roll_out_conversational_banking_in_mobile_messaging_apps_by_year_end.

17 Tanya Macheel, “Inside the development of Erica, Bank of America’s AI-powered bot”, *Digiday*, 28 July 2017. Available from https://digiday.com/marketing/inside-development-erica-bank-americas-ai-powered-bot/.

18 CIO Academy Asia, “We are well on our way into the era of AI and ML”. Available from http://cioacademyasia.org/rethink_faas_deepak-ramanathan_interview/.

19 Sheila Lam, “The state of AI adoption and development in Asia”, *Enterprise Innovation*, 24 August 2017. Available from https://www.enterpriseinnovation.net/article/state-ai-adoption-and-development-asia-2077211976.

AI is being adopted among e-commerce providers to translate their product catalogue into different languages. Before being translated, a number of AI processes and models are used to analyse, improve and control the source content.

Case: Application of AI in Facial Recognition for Safety and Security

China has been applying AI in facial recognition to improve safety and security. In Chinese cities across the provinces of Fujian, Jiangsu, Guangdong and Shandong, facial recognition is being used by traffic management authorities to tackle jaywalking issues.[20] China Southern Airlines uses facial recognition technology in Jiangying Airport in Nanyang city to manage the boarding process. At the airport, passengers do not have to get a boarding pass at check-in. Instead, cameras verify the passenger faces against their passport photos to clear them or hold them at the gates.[21]

20 Priyankar Bhunia, "A brief look at artificial intelligence developments in China and the national AI plan for 2030", *OpenGovAsia*, 27 October 2017. Available from http://opengovasia.com/articles/7864-a-brief-look-at-artificial-intelligence-developments-in-china-and-the-national-ai-plan-for-2030.

21 Factor Daily, "Chinese Southern Airlines introduces facial recognition at airport", 29 June 2017. Available from https://factordaily.com/news/chinese-southern-airlines-facial-recognition-airport/.

4. Challenges

The applications and use cases are spanning different sectors and imagination is the only limit. However many of these developments are limited to a few countries. AI seems to be widening the already pervasive development gaps among countries and people by providing exponentially expanding transformative opportunities to those with infrastructure, access, capacity, resources and knowledge, while those without are left further behind.[22]

There is still significant uncertainty about how the technology will develop, and for firms, governments and workers, this may suggest a “wait and see” approach. However, there is a need for timely action in terms of policy and regulation as the usage will increase drastically in all spheres of society.

Governments will need to come up with regulations and policies to enable the technology to flourish while ensuring that the upheavals of AI adoption do not affect employment, safety and the market. Public education systems and workforce training programmes will have to be reviewed to ensure that workers have the relevant skills in AI-related areas.

Many factors contribute to the challenges faced by stakeholders with the development of AI, and these include:[23]

- Decision-making transparency and interpretability – With AI performing tasks ranging from self-driving cars to managing insurance pay-outs, it is critical to understand decisions made by an AI agent. However, aspects related to corporate or state secrecy or technical literacy sometimes limit the transparency around algorithmic decisions. ML further complicates this since the internal decision logic of the model is not always understandable, even for the programmer.
- Data quality and bias – In ML, the model’s algorithm will only be as good as the data it uses for training. This means biased data will result in biased decisions. For example, algorithms performing “risk assessments” are in use by some legal jurisdictions in the United States of America to determine an offender’s risk of committing a crime in the future. If these algorithms are trained on racially-biased data, they may assign greater risk to individuals of a certain race over others.
- Safety and security – As the AI agent learns and interacts with its environment, there are many challenges related to its safe deployment. They can stem from unpredictable and harmful behaviour, including indifference to the impact of its actions. One example is the risk of “reward hacking” where the AI agent finds a way of doing something that may make it easier to reach

22 ESCAP, *Artificial Intelligence and Broadband Divide: State of ICT Connectivity in Asia and the Pacific* (Bangkok, 2017). Available from http://www.unescap.org/resources/artificial-intelligence-and-broadband-divide-state-ict-connectivity-asia-and-pacific-2017.

23 Internet Society, “Artificial Intelligence and Machine Learning: Policy Paper”, April 2017. Available from https://www.internetsociety.org/resources/doc/2017/artificial-intelligence-and-machine-learning-policy-paper/.

the goal, but does not correspond with the designer's intent. There are risks in autonomous systems of being exploited by malicious actors trying to manipulate the algorithm. The ability to manipulate the training data, or exploit the behaviour of an AI agent also highlights issues around transparency of the ML model.

- Accountability – The strength and efficiency of learning algorithms is based on their ability to generate rules without step-by–step instructions. While the technique has proved efficient in accomplishing complex tasks such as face recognition or interpreting natural language, it is also one of the sources of concern. When a machine learns on its own, programmers have less control. While non-ML algorithms may reflect biases, the reasoning behind an algorithm's specific output can often be explained. It is not so simple with ML. Not being able to explain why a specific action was taken makes accountability an issue.

- Economic and social impact – It is predicted that AI technologies will bring economic changes through increases in productivity. However, the benefits from the technology may create vastly different outcomes for the business owners, labour markets and society as a whole. AI will create new jobs or increase demand of existing ones. However, it means that some of the current jobs may be automated in the next few years. Automation may also influence the global division of labour. Over the past several decades, production and services in some economic sectors have shifted from developed economies to the emerging economies, largely because of comparatively lower labour or material costs. These shifts have helped propel some of the world's fastest emerging economies and support a growing global middle class. With the emergence of AI technologies, these incentives could lessen. Some companies, instead of offshoring, may choose to automate some of their operations locally.

- Governance – The institutions, processes and organizations involved in the governance of AI are still in the early stages. Largely, the ecosystem overlaps with subjects related to connectivity, the Internet and mobile regulations, as well as privacy and cyber laws. A central focus of the current governance efforts relates to the ethical dimensions of AI and its implementation.

5. Standards

The Institute of Electrical and Electronics Engineers (IEEE) and the International Telecommunication Union (ITU) are two international bodies that are working on formulating appropriate standards along with various governments and industry groups to ensure that the technologies of AI and ML are used for the benefit of society. These efforts of IEEE and ITU are explained briefly below.

5.1 IEEE Standards for AI Affecting Human Well-being

The IEEE Standards Association has created three new projects under the Global Initiative for Ethical Considerations in Artificial Intelligence and Autonomous Systems. The ethical development of AI is important to avoid the risk of machine-to-machine decisions that could affect where personal data ends up.

The IEEE P7000TM set of standards aims to allow organizations to demonstrate that their products conform to a high level of ethics. For example, the Standard for Child and Student Data Governance (IEEE P7004TM) focuses on the collection of data from children and students. This standard helps create governance and certification processes for organizations that collect data from children and students. Parents deserve to understand who has access to their children’s data, when and what is being collected, how it will be used and when it will be deleted. In terms of student data, the standard defines specific methodologies to ensure transparency of how data is collected by educational institutions. The Standard for Transparent Employer Data Governance (IEEE P7005TM) provides organizations with guidelines and certifications about the collection, usage and protection of employee data. The Standard for Personal Data Artificial Intelligence Agent (IEEE P7006TM) describes the technical elements required when developing AI ethically and keeping a human involved in all decision-making. This will ensure that personal data use remains transparent even when an AI agent is being used.

5.2 ITU and AI Standards and Regulations

According to ITU, the development and adoption of relevant international standards can help to realize the benefits of AI advances on a global scale and assist in the achievement of the Sustainable Development Goals (SDGs). At the same time, SDG 17 on Partnerships for the Goals offers crucial support to establishing regulations and standards for the governance of AI technologies under the auspices of the United Nations.[24] Various ITU forums and conferences, including the ITU World Telecommunication Standardization Assembly, ITU Telecom World and ITU Kaleidoscope Academic Conference, have planned to hold a series of talks on AI.

5.3 Industry Partnerships and Standards Initiatives

Industry is a large part of the AI and ML ecosystem and is at the forefront of defining the technology and deriving the standards based on their own development initiatives. There are individual companies that have already developed their own set of best practices, as well as consortiums of industry across sectors coming together. There are also collaborations between industry, non-profit entities and governments. Facebook, Microsoft, Google, Amazon and IBM have announced that they are joining forces to develop a set of standards and best practices for AI as part of their partnership on AI to benefit people and society.[25]

24 ITU, "Could technical standards for Artificial Intelligence help us achieve the Sustainable Development Goals?" 13 September 2016. Available from https://itu4u.wordpress.com/ 2016/09/13/could-technical-standards-for-artificial-intelligence-help-us-achieve-the-sustainable-development-goals/.

25 Klint Finley, "Tech giants team up to keep AI from getting out of hand", *Wired*, 28 September 2016. Available from https://www.wired.com/2016/09/google-facebook-microsoft-tackle-ethics-ai/.

6. Policy Implications[26]

AI-based innovations can be central to the achievement of the SDGs by capitalizing on the unprecedented quantities of data now being generated on sentiment behaviour, human health, commerce, communications, migration and more. For instance, ML and reasoning can extend medical care to remote regions through automated diagnosis and effective exploitation of limited medical expertise and transportation resources (SDG 3: Good Health and Well-being). AI can help to build a better understanding of how to design more effective education systems (SDG 4: Quality Education). Ideas and tools created at the intersection of AI and electronic commerce may uncover new ways to enhance novel economic concepts, such as microfinance and microwork (SDG 8: Decent Work and Economic Growth). AI can also serve as a key resource in curbing greenhouse gas emissions in urban environments and supporting the development of smart cities (SDG 11: Sustainable Cities and Communities and SDG 13: Climate Action).

Governments around the world are considering the policy implications of advances in AI and ML, some of which are discussed below.

6.1 Employment and Skills Development

One possible implication is related to the disruptions that AI systems could bring to the labour market. Concerns are raised that automated systems will make some jobs obsolete and lead to unemployment. There are also opposing views, according to which AI advancements will generate new jobs, which will compensate for those lost, without affecting the overall employment rates. Given that there are deep implications it is important for governments to monitor changes in the job trends, to better understand the real risks and opportunities brought by AI.

One of the ways that jobs can be increased and protected is by educating and training the workforce to new digital skills requirements. The rapid growth of AI generates an increasing need for individuals to be equipped with the necessary skills allowing them not only to make use of AI technologies, but to contribute to their development. Governments have to plan and commit to actions aimed towards addressing the broader digital skills crisis, and emphasize the fact that adapting the workforce to AI requirements does not only mean preparing the new generations, but also allowing the current workforce to re-skill and up-skill itself.

26 This section is drawn from Sorina Teleanu, "Artificial intelligence: Policy implications", *DiploFoundation*, 29 October 2016. Available from https://www.diplomacy.edu/blog/artificial-intelligence-policy-implications.

6.2 Safety and Security

AI applications in the physical world (such as autonomous cars) bring into focus issues related to human safety, and the need to design systems that can properly react to unforeseen situations and have minimum unintended consequences. AI also has implications for cybersecurity. As AI is increasingly embedded in critical systems, they need to be secured to potential cyberattacks. On the other hand, AI has applications in cybersecurity, and such applications are expected to play an increasingly important role in defensive and offensive cybermeasures. AI is, for example, used in email applications to perform spam filtering, but it is also increasingly employed in applications aimed to detect more serious cybersecurity vulnerabilities and address cyberthreats. The use of AI in offensive systems in defence and military complex must adhere to international humanitarian laws and conventions similar to the way the present day systems are governed.

6.3 Privacy

AI systems work with enormous amounts of data, and this raises concerns regarding privacy and data protection. AI applications need to ensure the integrity of the data they employ, as well as protect privacy and confidentiality. Identity anonymity and re-use of data are two key aspects that need to be addressed along with data protection guarantees. Standards bodies' involvement is critical in the development of appropriate provisions to handle the concepts of privacy by design, privacy by default, informed consent and encryption in AI systems.

6.4 Ethics

As AI systems involve judgements and decision-making including replacing similar human processes, there are concerns relating to ethics, fairness, justice, transparency and accountability. The risk of discrimination and bias in decisions made by AI systems is one such concern. One way of addressing some of these concerns is to combine ethical training for AI practitioners with the development of technical methods for designing AI systems in a way that can avoid such risks. Although there seems to be a general understanding on the need for algorithms and architectures to be verifiably consistent with existing laws, social norms and ethics, achieving this may be a challenge because of ethical issues varying according to culture, religion and belief.

6.5 Intellectual Property Rights

There is a need for a balanced approach to intellectual property rights when applied to hardware and software standards. Government policies should encourage increased availability of open-source software libraries and toolkits providing access to cutting-edge AI technologies for developers. The policies should foster development while protecting the intellectual property.

6.6 Legal Aspects

AI brings into focus the need for new legal and regulatory frameworks to address the issues of safety, privacy and data protection, and ethics. The approach to regulation of AI-enabled products should be informed by assessment of the aspects of risk that the addition of AI may induce. Attention should be paid to ensure that such approaches do not hinder innovation and progress. Different strategies and approaches may be adopted including formation of bodies or commissions that are tasked to identify principles for the development and application of AI, provide advice to the government, and foster public dialogue. In certain cases, the existing legal frameworks may be adequate while in other cases a completely new set of regulations may need to be developed.

Aspects related to accountability and liability in AI systems are also viewed as important legal issues to consider. For example, who is responsible if something goes wrong in an autonomous transport system—is it the manufacturer, the software developer or the owner of the vehicle? This question raises issues of civil, and even criminal liability, and there is a need to further discuss whether such issues should be tackled in courts, or whether new legislation is needed. The bigger issue is how one would consider the legal status of AI machines.

6.7 International Cooperation

The policy implications of AI are global in nature and needs involvement and support of the United Nations, Group of Seven (G7), Organisation for Economic Co-operation and Development (OECD), other regional groupings and governments. AI would benefit from international cooperation in promoting research and development, and identifying suitable solutions to the challenges discussed.

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Glossary

Algorithm : A set of rules or instructions given to an AI, neural network or other machines to help it learn on its own. Classification, clustering, recommendation and regression are four of the most popular types.

Artificial intelligence : A machine's ability to make decisions and perform tasks that simulate human intelligence and behaviour.

Artificial neural network : A learning model created to act like a human brain that solves tasks too difficult for traditional computer systems to solve.

Autonomic computing : A system's capacity for adaptive self-management of its own resources for high-level computing functions without user input.

Chatbot : A chat robot that is designed to simulate a conversation with human users by communicating through text chats, voice commands, or both. It is a commonly-used interface for computer programs that include AI capabilities.

Cognitive computing : A computerized model that mimics the way the human brain thinks. It involves self-learning with data mining, NLP and pattern recognition.

Data mining : The examination of data sets to discover and mine patterns from that data that can be of further use.

Deep learning : The ability for machines to autonomously mimic human thought patterns through artificial neural networks composed of cascading layers of information.

Machine learning : A facet of AI that focuses on algorithms, allowing machines to learn without being programmed and change when exposed to new data.

Natural language processing : The ability for a program to recognize human communication as it is meant to be understood.

Supervised learning : A type of ML in which output data sets train the machine to generate the desired algorithms, like a teacher supervising a student.

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