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AI as a Disruptive Technology

The world currently and will in the future experience economic and social changes which will alter society in nearly all of its manifestations so as to make it almost unrecognizable as it exists today. This occurrence is unique because of the rapidity in which it is taking place, all due to technological advances that have spread even to the poorest segments of society. Consider the effect of miniaturization on cell phones, computers, and other devices in addition to innumerable other innovations. These advances are incredibly exhilarating and also frightening to those persons who lack knowledge or capabilities to keep pace with the immense transformations. Not many decades ago an individual could pursue a course of studies which would permit a lifetime of work and comfort. Today, no assurance can be made to anyone that his or her knowledge or skill base will be sufficient to last more than a few years.

The Four Industrial Revolutions

We are in the midst of a Fourth Industrial Revolution. The First Industrial Revolution, which took place in the eighteenth century and continued onto the nineteenth century, witnessed the change from an agrarian

R. Girasa, *Artificial Intelligence as a Disruptive Technology*,
https://doi.org/10.1007/978-3-030-35975-1_1

society (consider that 97% of individuals in early America were farmers) to an industrial society promoted by steam and water. The Second Industrial Revolution, generally attributed to the years between 1870–1914, was characterized by newly discovered forms of energy such as electricity, oil, and steel that became the bases from which evolved the inventions of the telephone, light bulbs, and internal combustion engine. The Third Revolution refers to the modern-day advances in technology, e.g., miniaturization which was the foundation of the use of computers by any individual; the Internet that gave access to the world of knowledge without the need to leave one's desk; and advances in communication such as cell phones, Facebook, Instagram, Twitter, and other comparable devices and social media. This text discusses the transformative changes that are taking place today and which have been described as the "Fourth Industrial Revolution."[1]

Disruptive Technologies

The advances of technology, i.e., the practical applications of knowledge over the past several decades, have escalated exponentially with the creation of micro-computer chips coupled with the Internet all of which has transformed how we think, act, learn, and go about our daily personal and business-related activities. The current so-called "hot area" resulting therefrom that has encouraged enormous investments of time and money and which has become "disruptive" in daily living is the proliferation of cryptocurrencies with their bases in *blockchain* technology (the *first disruptive technological development*). A *second disruptive technological development* is that of *artificial intelligence* ("AI" hereafter). Both developments have the potential of creating vast changes in the way we behave and go about our daily activities. Disruption is a fact of life that continually occurs whenever new inventions and processes enter the marketplace.

[1] Jacob Morgan, *What is the Fourth Industrial Revolution?* FORBES (Feb. 19, 2016) https://www.forbes.com/sites/jacobmorgan/2016/02/19/what-is-the-4th-industrial-revolution/#3a92fc57f392.

This author wrote about the first major prong of the disruptive technologies that characterize the Fourth Industrial Revolution in his book, REGULATION OF CRYPTOCURRENCIES AND BLOCKCHAIN TECHNOLOGIES (Palgrave Macmillan, 2018).

The naysayers' fear, with some justification, that numerous jobs will be lost as a result of innovation; but changes also bring about a transformation evidenced by new jobs, directly or indirectly, brought about by the new technologies.

Stages of Disruptive Technologies. Scholars who have commented on the stages of disruption of existing modes of doing business generally assert a three-stage process, while other scholars emphasize as many as five stages. For example, one scholar contended that the three stages consist of an initial *paralysis stage* whereby the disruption is unanticipated and thus not planned, e.g., Amazon's entry into the book sales marketplace; then proceeds to a *reaction stage* whereby the affected company comes to the realization of the threat to its existence or market share and advances in a number of ways to thwart the onslaught, e.g., by political lobbying for protection, making small improvements, and other reactive efforts; and finally, the *third transformation stage* whereby the affected company institutes major changes within the firm. This last stage occurs with the firm, e.g., adding new technological tools, building customer relations, merging with other companies similarly affected, expanding its ability to offer additional services or product lines, establishing a center for excellence, additional advertising, and other efforts.[2] Another commentator suggested a five-stage process of *confusion* (not sure what is occurring), *repudiation* (claiming lack of importance), *shaming* (saying, e.g., it is just a fad), *acceptance* (realization that the new entrant is for real), and *forgetting* (minimizing past behavior and adaptation to new circumstances).[3]

The creators of blockchain technology sought a mechanism by which persons could transact their daily business and personal happenings by bypassing third parties while also preserving personal safety, and by permanent recordation of transactions. AI likewise will be as transformative to our daily lives. There are, of course, other disruptive technologies; however, this author believes the two technologies cited have the greatest futuristic impact. Some authors exhibit a listing of a dozen or so

[2] Mike Bainbridge, *3 Phases of Disruption*, DISRUPTION HUB (May 4, 2017), https://disruptionhub.com/3-phases-distruption/.

[3] Grant McCracken, *The Five Stages of Disruption Denial*, HBR (April, 2013), https://hbr.org/2013/04/distruption-denail.

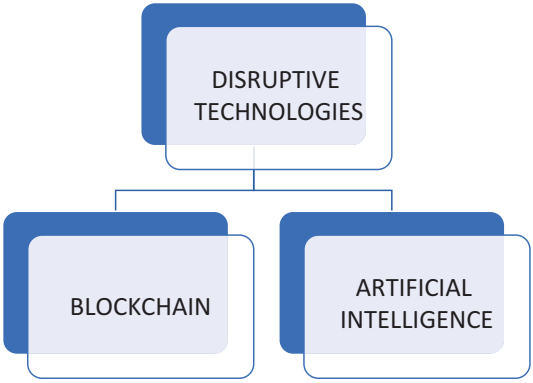

Fig. 1.1 Major disruptive technologies

disruptive technologies but most are based on AI technology.[4] This text will examine the meaning of AI, its rapid developments and uses, the benefits and risks, and whether and to what extent should regulatory agencies become concerned about protection against harmful misuse thereof (Fig. 1.1).[5]

Artificial Intelligence (AI)

AI Antecedents. Historically, the words "Artificial Intelligence" were first coined by John McCarthy in 1955 in a proposal for a conference to be held at Dartmouth College. He was a computer scientist who taught mathematics therein and later founded AI laboratories both at MIT and Stanford. The six-week Dartmouth Conference of 1956 became a seminal event in which artificial intelligence or thinking machines was first enunciated in an organized manner and in which additional topics were

[4] Examples include: mobile internet, Internet of Things (discussed in Chap. 5), automation of knowledge work, advanced robotics, cloud, autonomous or semi-autonomous vehicles, next generation genomics, next generation storage, 3D printing, advanced materials, advanced oil and gas exploration and recovery, and renewable energy. Maria Fonseca, *Guide to 12 Technology Examples*, Intelligent HQ (March 2, 2014), https://www.intelligenthq.com/technology/12-disruptive-technologies/.

[5] For a lengthy itemized history of AI from which this discussion relied on, see *A Brief History of AI*, AI TOPICS, https://aitopics.org/misc/brief-history.

discussed such as neural networks, natural language progressing, and other topics now commonplace in today's depictions of the numerous subsets of AI. McCarthy believed that "every aspect of learning or any other feature of intelligence can in principle be so precisely described that a machine can be made to simulate it."[6] AI has a long history in a broad sense extending back as early as the fourth century B.C. to Aristotle who invented syllogistic logic, the first formal deductive reasoning system. Thereafter, AI is traceable successively to 1206 A.D. whereby Al-Jasari invented the first programmable humanoid robot; the invention of the printing press in the fifteenth century; the first mechanical digital calculating machine by Pascal in 1642; and the numerous mathematical advances of the first half of the 20th particularly by Bertrand Russell and Alfred North Whitehead in their treatise on formal logic in *Principia Mathematica*. The more recent history has witnessed greatly increased understanding of AI with technology companies coming into existence, advances in computer technology that explored its uses, and numerous other programs that enabled highly significant revolutionary advances in technological development.

Preceding McCarthy's coining of AI was the remarkable effort of Alan Turing, famed for his effort in decrypting the German enciphering machine, Enigma, which was a major factor in aiding Allied efforts to end World War II victoriously. He was particularly known for his "Turing machine" which strived to imitate the human mind by the use of a precise mathematical formulation of computability. He sought to create a machine which could play chess, i.e., with thought processes emulating the human brain. He conceived of an apparent contradictory expression "machine intelligence" whereby a machine was thought of by its very nature to be incapable of intelligence. He expressed the hope and desire to create robotic machines that could eventually compete with human intelligence. The concept had broad philosophical and societal implications as well as a scientific mathematical basis which became increasingly

[6] Martin Childs, *John McCarthy: Computer scientist known as the father of AI*, INDEPENDENT (Nov. 1, 2011), https://www.independent.co.uk/news/obituaries/john-mccarthy-computer-scientist-known-as-the-father-of-ai-6255307.html.

relevant in later decades.[7] We will discuss Turing's contributions further in Chap. 8.

The chess victory by the IBM Deep Blue known as "Watson" in 1997 over two of the world's best chess players, with its ability to analyze some 200 million possible chess positions in front of an international audience, gave credence to Turing's formulation.[8] The latest emanation of non-human triumph over human intelligence was Alphabet's U.K.-based AI DeepMind's AI bot, "AlphaStar," which defeated a champion professional player in the complex real-time strategy videogame, StarCraft II.[9] By such enhancement of credibility, creators of the innumerable formulations of AI began to take note of the possibilities previously not feasible to consider. Thus, the said AI development has given credence to the said fears of job losses and other possible negative consequences while also simultaneously bringing about vast improvements in productive capacities of workers at all levels of corporate governance and production, expanded life expectancies, and, ultimately, attain interplanetary or even inter-stellar occupation.

Definitions of AI

There are numerous definitions of "AI" dependent upon the particular profession or activity. A sampling of definitions is as follows:

- AI is "the ability of a digital computer or computer-controlled robot to perform tasks commonly associated with intelligent beings."[10]

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[7] *Alan Turing*, STANFORD ENCYCLOPEDIA OF PHILOSOPHY, rev. Sept. 30, 2013, https://plato.stanford.edu/entries/turing/.

[8] *Deep Blue*, IBM 100, https://www.ibm.com/ibm/history/ibm100/us/en/icons/deepblue/.

[9] Tom Simonite, *DeepMind Beats Pros at Starcraft in Another Triumph for Bots*, WIRED (Jan. 25, 2019), https://technewstube.com/wired/1074075/deepmind-beats-pros-at-starcraft-in-another-triumph-for-bots/.

[10] *Artificial Intelligence*, ENCYCLOPAEDIA BRITANNICA, https://www.britannica.com/technology/artificial-intelligence.

- AI is "the study and design of intelligent agents" where an intelligent agent is a system that perceives its environment and takes actions which maximizes its chances of success.[11]
- AI is "[T]he 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."[12]
- "Artificial intelligence (AI), sometimes called machine intelligence, is intelligence demonstrated by machines, in contrast to natural intelligence displayed by humans and other animals."[13]
- Artificial Intelligence is defined, in current U.S. legislation, as "(A) Any artificial system that performs tasks under varying and unpredictable circumstances without significant human oversight, or that can learn from experience and improve performance when exposed to data sets. (B) An artificial system developed in computer software, physical hardware, or other context that solves tasks requiring human-like perception, cognition, planning, learning, communication, or physical action. (C) An artificial system designed to think or act like a human, including cognitive architectures and neural networks. (D) A set of techniques, including machine learning, that is designed to approximate a cognitive task. (E) An artificial system designed to act rationally, including an intelligent software agent or embodied robot that achieves goals using perception, planning, reasoning, learning, communicating, decision-making, and acting."[14]

[11] *Artificial Intelligence*, SCIENCE DAILY, https://www.sciencedaily.com/terms/artificial_intelligence.htm.

[12] *Artificial Intelligence*, OXFORD LIVING DICTIONARY, https://en.oxforddictionaries.com/definition/artificial_intelligence.

[13] *Artificial Intelligence*, WIKIPEDIA, https://en.wikipedia.org/wiki/Artificial_intelligence.

[14] NATIONAL SECURITY COMMISSION ON ARTIFICIAL INTELLIGENCE ACT OF 2018, S. 2806, 115th Cong. (2018), https://www.congress.gov/115/bills/s2806/BILLS-115s2806is.pdf.

Types of AI Intelligence

AI may be characterized as *Artificial Narrow Intelligence* (ANI), *Artificial General Intelligence* (AGI), and *Artificial Superintelligence* (ASI). ANI is depicted as "weak" intelligence because it concerns the performance of a singular task which it generally accomplishes very well as, e.g., playing chess against human experts, making sales predictions, autonomously driving automobiles, and may, at this juncture, include speech and image recognition. "Weak" is used in the sense of its limitation to the one task rather than having a broader usage.[15] AGI, also known as "Strong AI" or "Human-Level AI," is the next higher level of AI progression in that it seeks to imitate the human brain, albeit its development continues to lack the reasoning and other attributes of the brain. ASI is a futuristic characterization which will disputably occur when AI has surpassed the capacity of the human brain in creativity, social skills, and wisdom.[16] This last development poses unique challenges that potentially are extraordinarily beneficial or detrimental to society. Whether a particular robot is either an ANI or AGI depends on whether it meets the *Turing test* standard, i.e., whether its behavior resembles that of human and other measures. The more it resembles a human person, e.g., one working on an assembly plant, the more likely it would be characterized as an AGI.[17]

ASI is the focus of innumerable sci-fi books, articles, movies, and the like about robots becoming so intelligent as to make humans subject to their control. A noted book which explores intellectually the options and possibilities of ASI is MIT scientist, Max Tegmark's, *Life 3.0*, which examines the expansion of AI from its earlier promulgations to the possibility of ASI. He stated that to arrive at the ASI stage, three logical steps are required: Step 1: Build human-level AGI; Step 2: Use this AGI to create superintelligence; and Step 3: Use or unleash this superintelligence

[15] Ben Dickson, *What is Narrow, General, and Super Artificial Intelligence?*, TECHTALKS (May 12, 2017), https://bdtechtalks.com/2017/05/12/what-is-narrow-general-and-super-artificial-intelligence/.
[16] *Id.*
[17] Tetiana Shevchenko, *3 Types of Artificial Intelligence Everyone Knows About*, LETZGRO (Aug. 10, 2016), http://letzgro.net/blog/3-types-of-artificial-intelligence/.

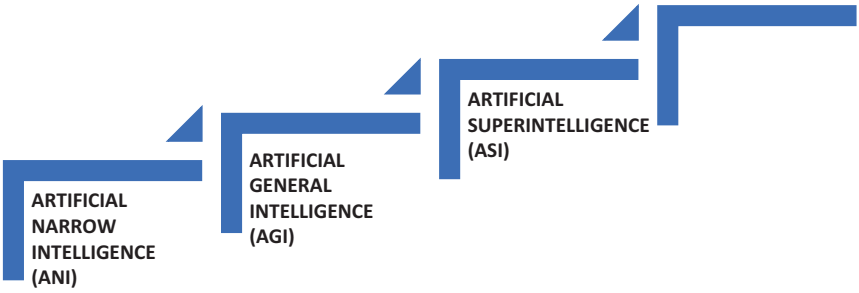

Fig. 1.2 Types of artificial intelligence

to take over the world.[18] He surmises that it is unclear whether ASI will lead to totalitarian control, especially if in the control of dictators as evidenced in the twentieth century by a Hitler or Stalin, or a more individual empowerment. The AI scenario offers a very wide range of possibilities from a libertarian utopia, wherein humans, "cyborgs," uploads, and superintelligences co-exist peacefully, to the 1984 superintelligence led by an Orwellian surveillance state, or to self-destruction by humans (Fig. 1.2).[19]

Another classification of the kinds of AI intelligence states that there are four types, namely: (1) *reactive machines*, i.e., those that do not form memories or benefit from past experiences—the IBM that beat chess masters (equivalent to ANI above); (2) *limited memory*—able to benefit from past experience, e.g., autonomous automobiles (equivalent to AGI); (3) *theory of the mind*—form representations of the world, possess self-awareness and also construct representations about other agents in the world; and (4) *self-awareness*—able to form representations about themselves and possess consciousness—futuristic capability (equivalent to ASI).[20]

[18] MAX TEGMARK, LIFE 3.0: BEING HUMAN IN THE AGE OF ARTIFICIAL INTELLIGENCE, at 134 (Vintage Books, 2017).

[19] *Id.* at 162.

[20] Aaron Hintze, *Understanding the Four Types of Artificial Intelligence*, GOVERNMENT INTELLIGENCE (Nov. 14, 2016), http://www.govtech.com/computing/Understanding-the-Four-Types-of-Artificial-Intelligence.html.

Yet again, AI could be thought of, as stated in Fortune Magazine by Kai-Fu Lee, a venture capitalist and former head of Google China and CEO of Sinovation Ventures, as possessing four waves that are occurring simultaneously which characterized AI's ascendance to prominence: *First Stage: Internet A.I.* whereby users, examining the vast amount of data derived from the Internet, label the data as buying or not, clicking or not, and so on and which reflects individual preferences, demands, habits, and desires seeking particular platforms to maximize profit; *Second Stage: Business A.I.* whereby, through the use of algorithms trained on proprietary data sets, managers can improve their decision-making by the analysis of customer purchases, machine maintenance, and complex business processes. Examples given are the use of deep-learning algorithms, which, the author stated, were game changers for AI, to the study of thousands of bank loans and repayment rates to reflect risks of default, and to medical researchers—to learn of optimum health outcomes from data on patient profiles and types of therapies used.[21]

Kai-Fu Lee's *Third Stage: Perception A.I.* is illustrated by the collection and analyses of data not previously accomplished such as that found in smart devices, smart interfaces, face recognition, and computer-vision applications; and, finally, the *Fourth Stage: Autonomous A.I.* whereby the previous three stages are integrated so that machines are able to perceive and react to the world from which the data flows, move instinctively, manipulate objects as a human person is enabled, "see" the environment around them, recognize patterns, determine how to correlate the data, make decisions such as in automated assembly lines and warehouses, implement commercial tasks, and perform consumer chores. The author minimizes fears that computers and robots are at the ASI stage stating that, at best, AI has attained only ANI progression, limited to a single domain standing, albeit the future may witness further advancement that should cause us to reflect on its monumental impact and benefits but also challenges therefrom.[22]

[21] Kai-Fu Lee, *The Four Waves of A.I.*, FORTUNE (Nov. 1, 2018) at 91–94, fortune.com/2018/10/22/artificial-intelligence-ai-deep-learning-kai-fu-lee/.

[22] *Id.* at 94.

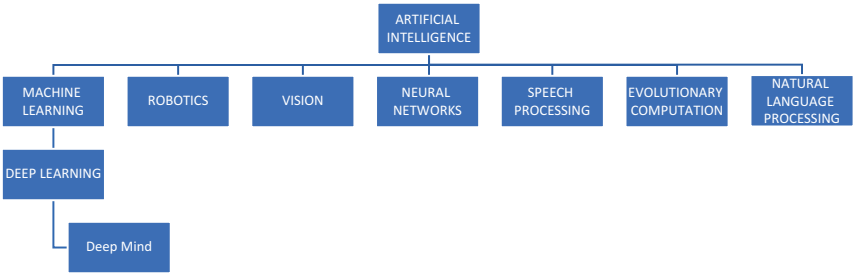

Fig. 1.3 AI partial subfields

Subfields of AI

The subfields of AI are as extensive as scientists, technologists, and other researchers can devise. One student-researcher recited 87 subfields albeit observing that some of them overlap.[23] Nevertheless, for purposes of this text and based on review of numerous citations, we note the following major subsets (Fig. 1.3).

Machine Learning

AI is the umbrella or generic expression which includes both machine learning and its subset of deep learning. All machine learning is AI but not the reverse. It is the science of training devices or software to perform a task and improve its capabilities by feeding it data and information so that it can "learn" over time without being explicitly programmed. The programs or algorithms therein enable machines to improve with added data. It may be sub-classified, using the categorization stated above, as *applied AI*, i.e., a narrower or weak version of AI and most commonly used whereby it is applied to machines to manage specific tasks, or *generalized AI* when applied can encompass any technology that can evolve and improve any task. Machine learning is expected to become more prominent in the forthcoming years. Sixty percent of all moneys invested

[23] Yasir Arfat, QUORA (April 17, 2016), https://www.quora.com/What-are-the-subfields-of-AI.

in AI was expended for machine learning.[24] In a 2016 McKinsey Global Institute Study, it noted that the total annual external investment in AI was between $8-to-12 billion and confirmed the said 60 percent machine learning expenditure noting that robotics and speech recognition garnered much of the said percentage.[25]

Deep Learning. Deep learning is a subset of machine learning which, in turn, is a subset of AI. It is usually referred to as *deep artificial neural networks*, or *deep reinforcement learning*.[26] It is concerned with algorithms[27] analogous to the human brain cells called neurons.[28] It is an artificial neural network modeled by use of layers of artificial neurons or computational units to receive input and apply an activation function along with the threshold.[29] As each massive layer of data is added, the machine undergoes a training process. The *deep* in *deep learning* describes all the layers and their interconnections in the neural network. If there is only one layer, then it is called a *hidden layer*. Applications include use in autonomous automobiles; recoloring of black and white images to restore colors that humans could recognize; prediction of the outcome of legal proceedings; prescription of medicines for the patient's particular genome; and assistance in breakthroughs in speech recognition, natural language processing, and robotics.[30]

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[24] *The Difference Between AI, Machine Learning & Robots*, DELL TECHNOLOGIES, https://www.delltechnologies.com/en-us/perspectives/the-difference-between-ai-machine-learning-and-robotics/.

[25] Louis Columbus, *McKinsey's State of Machine Learning and AI, 2017*, FORBES (July 9, 2017), https://www.forbes.com/sites/louiscolumbus/2017/07/09/mckinseys-state-of-machine-learning-and-ai-2017/#291e5bd175b6.

[26] *Artificial Intelligence (AI) vs. Machine Learning vs. Deep Learning*, SKYMIND, https://skymind.ai/wiki/ai-vs-machine-learning-vs-deep-learning.

[27] *Algorithm* is a set of instructions or procedure for performing a calculation or solving a mathematical problem generally by use of a computer.

[28] *Neurons* are electrically excitable cells in the nervous system that function to process and transmit information, SCIENCEDAILY, https://www.sciencedaily.com/terms/neuron.htm.

[29] Seema Singh, *Cousins of Artificial Intelligence*, TOWARDS DATA SCIENCE (May 26, 2018), https://towardsdatascience.com/cousins-of-artificial-intelligence-dda4edc27b55.

[30] Raja Mitra, *Understanding AI and the Shades of Difference among its Subsets*, MEDIUM.COM (May 6, 2017), https://medium.com/@montouche/understanding-ai-and-the-shades-of-difference-among-its-subsets-4c84b106d0c1.

DeepMind. DeepMind was created by British researchers Dennis Hassabis, Shane Legg, and Mustifa Suleyman in 2010 who sought to construct a neural network equivalent to AGI. Their research is based on generating a single program for application to games and which program is able to teach itself how to play and win at 49 completely different 2600 Atari games, as well as beat the player at Go, a very complex game.[31] Unlike ANI, it is not preprogrammed but learns from experience and thus is an AGI. It is currently applying its technology for environmental causes and for improvement of health care.[32] Among the environmental initiatives is the enabling of machine learning, through the use of a neural network that was inculcated on available weather forecasts and historical turbine data, to predict wind power output 36 hours before its actual generation. In so doing, the use of wind power became more feasible and enabled recommendations of how to make hourly delivery commitments to the power grid a day in advance. It transformed an unpredictable source into one with much more reliability (about 20 percent greater efficiency) and of great benefit to the environment.[33] *DeepMind Health*, through its Streams, is a secure mobile phone app that is able to pick up signs of medical conditions, such as sepsis and acute kidney injury, well before clinicians are enable to do so. It has purportedly saved numerous patients from injury and death.[34] It was acquired by Google in 2014 for $400 million which created its artificial neural network to play games as a human person and also as a Neural Turing Machine (NTM) to enable access to external memory (Fig. 1.4).[35] It is currently owned by Alphabet Inc.

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[31] *AlphaGo*, https://deepmind.com/research/alphago/.

[32] *Solve Intelligence. Use it to make the world a better place*, DEEPMIND, https://deepmind.com/about/.

[33] *Machine learning can boost the value of wind energy*, DEEPMIND, https://deepmind.com/blog/machine-learning-can-boost-value-wind-energy/.

[34] *How we're helping today*, DEEPMIND, https://deepmind.com/applied/deepmind-health/working-partners/how-were-helping-today/.

[35] For a discussion how the NTM seeks to mimic the human brain's short-term memory, see *Google's Secretive DeepMind Startup Unveils a "Neural Turing Machine,"* MIT TECHNOLOGY REVIEW (Oct. 29, 2014), https://www.technologyreview.com/s/532156/googles-secretive-deepmind-startup-unveils-a-neural-turing-machine/.

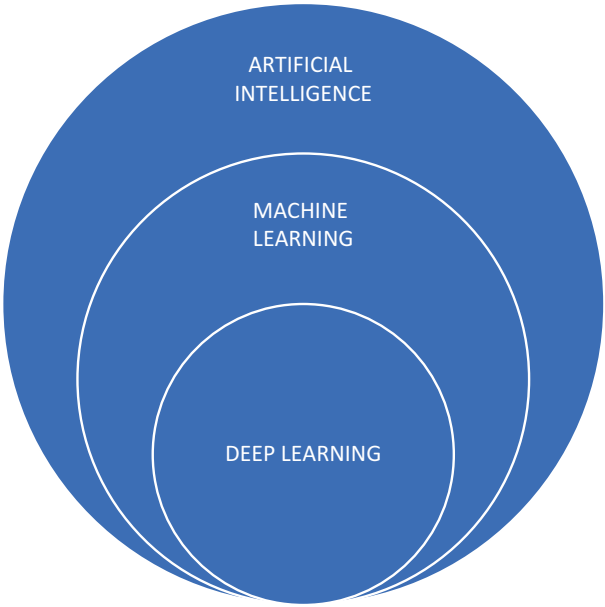

Fig. 1.4 Machine learning and deep learning. (Source: *Artificial Intelligence: The Road Ahead in Low and Middle-Income Countries*, WORLD WIDE WEB FOUNDATION (June, 2017) at 5, http://webfoundation.org/docs/2017/07/AI_Report_WF.pdf)

Robotics

Robotics is the science or study of technology associated with the design, fabrication, theory, and application of robots.[36] It is an interdisciplinary branch of science which comprises a number of types of engineering disciplines such as mechanical, electronic, and information engineering and computer systems.[37] In this text, we are particularly concerned with how AI-based robots are utilized. There are many types of robots whose applications are virtually numberless (discussed in Chap. 2).

[36] *Robotics*, THE AMERICAN HERITAGE DICTIONARY OF THE ENGLISH LANGUAGE, https://www.ahdictionary.com/word/search.html?q=robotics/.

[37] *Robotics*, WIKIPEDIA, https://en.wikipedia.org/wiki/Robotics.

Vision (Computer Vision)

Vision is a subfield of AI and is defined as the science and technology whereby AI systems are able to extract information, build models, and apply multi-dimensional data in a broad range of computer-generated activities.[38] There are a number of subfields of computer vision including computational vision (computer vision) and machine vision. *Computational vision* is the process of recording, analyzing, and comprehending visual images which are then utilized in machine vision for a variety of social and scientific purposes including the use of feature engineering to make machine learning algorithms operate efficiently.[39] Examples of uses of computational vision in AI are the Robocup tournament, i.e., tournament of robot dogs playing soccer by reacting to images received by the robots, and ASIMO, which is a Honda created robot that can analyze its environment, walk, talk, climb stairs, maneuver around objects, act as a companion to humans, and other features.[40] *Machine vision* is comprised of a number of technologies including systems engineering and, generally, is the application of computational vision in an industrial or practical application or process.[41]

Facial recognition is a sub-domain of computer vision which is able to extract data that can assist in identifying and/or verifying a particular individual from a digital image or video frame.[42] Heretofore, the most common mode of identification, particularly for police objectives, was the use of fingerprints, voice, eyes, and lineups. AI's facial recognition system, also known as a Biometric Artificial Intelligence, in conjunction

[38] Taniya Arya, *What is computer vision in artificial intelligence?*, QUORA, https://www.quora.com/What-is-computer-vision-in-artificial-intelligence.

[39] *Vision and AI*, VISION RECOGNITION, MBHA, https://mbhs.edu/~lpiper/computer_vision03/visionai.html.

[40] *Honda*, ASIMO, http://asimo.honda.com/downloads/pdf/asimo-technical-information.pdf.

[41] *Computer Vision vs. Machine Vision*, AIA VISION ONLINE, https://www.visiononline.org/vision-resources-details.cfm/vision-resources/Computer-Vision-vs-Machine-Vision/content_id/4585.

[42] Other sub-domains of computer vision are: scene reconstruction, event detection, video tracking, object recognition, 3D pose estimation, learning, indexing, motion estimation, and image restoration. *Computer vision*, WIKIPEDIA, https://en.wikipedia.org/wiki/Computer_vision.

with other biometrics such as eye (iris) recognition systems, has been used for a wide variety of additional purposes.[43] At sporting events, the system has been used to identify players, recognize visitors, celebrities, known criminals, and other possible troublemakers. It has been employed for advertising and for the identification of individuals, especially well-known persons at events, albeit it may run afoul of their privacy rights. Law enforcement has used it at police stops, sporting events, and other locations. Its application has expanded exponentially such as at international airports and it is estimated that the facial recognition market for it will reach $9.6 billion by 2022.[44] (Legal and ethical issues of facial recognition are discussed in Chap. 4.)

Artificial Neural Network

An artificial neural network (ANN) is a computational model based on the structure and functions of biological neural networks. Information that flows through the network affects the structure of the network because a neural network changes, or learns in a sense, grounded on that input and output.[45] It is based on observational analogical reasoning of the biological process of the human brain which is able to accomplish the connections of axons among its 86 billion nerve cells (neurons) from external stimuli. It was defined by the inventor of the first neurocomputers, Dr. Robert Hecht-Nielsen, as "…a computing system made up of a number of simple, highly interconnected processing elements, which process information by their dynamic state response to external inputs."[46] ANN seeks to imitate the process by learning from examples fed from complex data inputs. It is a framework for algorithms to work together.

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[43] *Facial recognition system*, WIKIPEDIA, https://en.wikipedia.org/wiki/Facial_recognition_system.

[44] *Facial Recognition Market Worldwide Expected to Reach $9.6 Billion by 2022*, HT HOSPITAL TECHNOLOGY (July 1, 2016), https://hospitalitytech.com/facial-recognition-market-expected-reach-96-billion-worldwide-2022.

[45] *Artificial neural network*, TECHOPEDIA, https://www.techopedia.com/definition/5967/artificial-neural-network-ann.

[46] *A Basic Introduction to Neural Networks*, http://pages.cs.wisc.edu/~bolo/shipyard/neural/local.html.

ANNs have been used to perform a variety of tasks such as computer vision, speech recognition machine translation, social network, medical diagnosis, video games, and other uses.[47]

Speech Processing

Speech processing has been defined as "the study of speech signals and processing methods … and is at the intersection of speech signals and natural language processing."[48] The signals are in digital format and includes the acquisition, manipulation, storage, transfer, and output of speech signals without use of hands or eyes. Speech processing poses many problems due to the vast number of forms of speech such as loudness or softness, accents, particular mode of speaking, use of language, and other characteristics. A viewer watching translations or recitations of discussions on television will note how often the speech download contains numerous inaccuracies. Thus, AI has been instrumental in creating greater reliability of setting forth accurately what has been stated by speakers. Individuals using speech processing software, particularly by disabled persons unable to type on computers persons, have specific needs for accuracy of statements made. Speech recognition software may be, as one scholarly paper defined, either *Speaker-Dependent*, whereby the computer software adapts to the particular mode of speech by an individual, or *Speaker-Independent* that is able with greater inaccuracies to transforms speech behavior by many persons with varying modes of speech.[49]

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[47] *Artificial neural network*, WIKIPEDIA, https://en.wikipedia.org/wiki/Artificial_neural_network; https://www.sciencedirect.com/topics/neuroscience/speech-processing.

[48] *Speech Processing*, SCIENCEDIRECT, https://www.sciencedirect.com/topics/neuroscience/speech-processing.

[49] G. Harsha Vardham and G. Hari Charan, *Artificial Intelligence and its Applications for Speech Recognition*, 3 INTERNATIONAL J. OF SCIENCE & RESEARCH, Issue 8 (Aug. 12, 2014), https://www.ijsr.net/archive/v3i8/MDUwODE0MDU=.pdf.

Evolutionary Computation

Evolutionary computation is a subfield of AI that is composed of algorithms that relate to the use of evolutionary systems as computational processes for solving complex problems. It is a tool used by scientists and engineers who commence a set of candidate solutions which is updated periodically through a process of trial and error. Each generation is produced stochastically (randomly determined), removing fewer desirable solutions coupled with random changes. In this manner, optimal solutions are periodically presented and altered to achieve maximum optimization.[50]

Natural Language Processing (NLP)

NLP is a subfield of AI that focuses on the interactions between computers and human language. It is at the intersection of computer science, AI, and computational linguistics and is concerned with how computers process and analyze large amounts of natural language data. Natural language is the way we humans communicate with each other through speech and text. NLP is the process of building computational tools that respect language by use of machine translation, summarization, questions and answers which draw upon a variety of scientific disciplines.[51]

In Chap. 2, we will explore some of the innumerable ways in which AI has and will continue to transform almost every aspect of society to a degree previously relegated to the realm of science fiction but now, in many ways, exceeds the creative imagination of earlier authors. This progression has come about with the expansion of computer technology that has enabled researchers to engage in the exploration of deep learning

[50] Kenneth A. DeJong, *Evolutionary Computation: A Unified Approach*, AMAZON CO UK, https://www.amazon.com/Evolutionary-Computation-Approach-Kenneth-Jong/dp/0262529602 and *Evolutionary Computation*, WIKIPEDIA, https://en.wikipedia.org/wiki/Evolutionary_computation.

[51] Jason Brownlee, *What is Natural Language Processing?*, MACHINE LEARNING MASTERY (Sept. 22, 2017), https://machinelearningmastery.com/natural-language-processing/; and Matt Kiser, *Introduction Language Processing*, ALGORITHMIA (Aug. 11, 2016), https://blog.algorithmia.com/introduction-natural-language-processing-nlp/.

neural networks. Human past history evolved rather slowly whereby major thinkers could predict events that will occur in the several decades to follow. In as brief a time as a decade from now, with the addition of quantum computing and other advances in computational technologies, the attempt to render an informed opinion will tax the predictive capabilities of the greatest of our futurists, the most prescient of our seers.