



Artificial Intelligence as a Disruptive Technology

Economic Transformation
and Government Regulation

Rosario Girasa

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To
Susanne Marolda and Kenneth Marolda
(Mother and Son)
Former Students Who Taught the Instructor

Other Publications by Author Under Name of Roy J. Girasa or Rosario Girasa

Cyberlaw: National and International Perspectives (Prentice-Hall, 2002)
Corporate Governance and Finance Law (Palgrave Macmillan, 2013)
Laws and Regulations of Global Financial Markets (Palgrave
Macmillan, 2013)
Shadow Banking: Rise, Risks, and Rewards of Non-Bank Financial
Services (Palgrave Macmillan, 2018)
Regulation of Cryptocurrencies and Blockchain Technologies (Palgrave
Macmillan, 2018)

Preface

I had written a book entitled “Regulation of Cryptocurrencies and Blockchain Technologies,” which was published in July, 2018. A former student came to my university office who told me about her position at a “big-4” accounting firm which had called in all of the employed accountants and announced the firm’s new priorities, namely, blockchain and artificial intelligence. Both are transformative developments that will occur exponentially in the coming years. Although there are thousands of articles and many books on artificial intelligence (AI), this text is aimed at fulfilling a perceived need for the regulatory aspect of AI. The goal of this text is that it will assist in that regard.

It is almost without precedent that a subject matter encompasses the broadest spectrum of human knowledge. At first blush, AI is the emanation of the immense research, testing, and expansion of the scientific frontiers encompassing the pure sciences of physics, chemistry, and biology, utilizing the language of mathematics based in great part to the creation and exponential growth of computers. The rise of robotics brings to the forefront the social sciences which include sociological issues especially that of job losses or substitutions; economics which is profoundly affected by the effects of AI creations both nationally and globally; political science which is concerned with how governments respond to the challengers wrought by the new technologies including military uses; psychology concerning AI’s effect on the many changes in jobs and social

norms that new generations will experience; arts, literature, movies, and the entertainment industry in general with the many fantasies and possibilities of AI which have featured numerous works of fiction and movies of robots and other AI advances as they interrelate to human persons; philosophy, especially concerning the concept of consciousness in robots should they attain the level of superintelligence; and other areas of human knowledge.

Having attained more than eight decades of life, no other subject matter has ever intrigued this author as AI, having made research and writing totaling, engrossing, and endlessly fascinating. I truly wish upon the reader a desire to explore this area of knowledge which will profoundly affect all of our future lives.

Special thanks to Professor Victor Lopez of Hofstra University, Dr. Sharlene A. McEvoy of Fairfield University, and John Hardiman, who is an engineer and past editor of Delmar for their interest and opinions. Also special thanks to Rachael Ballard, Head of Science and Society for Palgrave Macmillan for her review, support, and furthering the production of this text; Joanna O'Neill, Assistant Editor at Palgrave Macmillan for walking me through the editorial process; G. NirmalKumar for his excellent editorial assistance; and my very special program advisers at Pace University, Patricia Saviano and Suzanne DeRosa for all their invaluable assistance.

Please note. This author researched all of the material and wrote all of the words except for quotes stated in the text and, thus, all errors are those of the author. The text is not intended to offer legal advice but rather is the author's analysis and opinions based on the numerous articles, commentaries, speeches, regulations, and other materials read and downloaded in an attempt to understand the new technologies and provide a text in readable format for students, professors, and all other interested persons in the subject matter. For all personal, legal, and related questions, refer to competent counsel for up-to-date advice and suggestions.

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Acronyms and Abbreviations

ACLU	American Civil Liberties Union
AGI	Artificial general intelligence
AI	Artificial intelligence
AIE	Artificial Intelligence Exploration
AIRA	Artificial Intelligence Research Associate
ANI	Artificial narrow intelligence
ANN	Artificial neural network
API	Application programming interface
ASI	Artificial superintelligence
ASPEN	Automated Scheduling and Planning Environment System
ATEAC	Advanced Technology External Advisory Council
ATM	Automated teller machine
CBP	Customs and Border Protection
CCW	Convention on Certain Conventional Weapons
CDS	Credit default swaps
CDT	Center for Democracy & Technology
CIA	Central Intelligence Agency
COiN	Contract Intelligence
COPPA	Children's Online Privacy Protection Act
DARPA	Defense Advanced Research Projects Agency
DESA	Department of Economic and Social Affairs
DHS	Department of Homeland Security
DoD	Department of Defense

xiv Acronyms and Abbreviations

DoE	Department of Energy
DoT	Department of Transportation
E.U.	European Union
ECOSOC	Economic and Social Council
EEA	Economic Espionage Act
EPO	European Patent Office
ERF	European Robotics Forum
FAA	Federal Aviation Administration
FCC	Federal Communications Commission
FDA	Food and Drug Administration
FICO	Fair, Isaac and Company (original company name)
FIPPs	Fair Information Practice Principles
FLI	Future of Life Institute
FMCSA	Federal Motor Carrier Safety Administration
FMVSS	Federal Motor Vehicle Safety Standards
FTC	Federal Trade Commission
GDP	Gross domestic product
GDPR	General Data Protection Regulation
GGE	Group of Governmental Experts
GPS	Global positioning system
GVA	Gross value added
HIPAA	Health Insurance Portability and Accountability Act
HR	Human Resources
HTML	Hypertext markup language
HVAC	Heating, ventilation, and air conditioning
IBM	International Business Machines
ICRAC	International Committee for Robot Arms Control
ICT	Information and communications technology
IoT	Internet of Things
IPE	Intellectual Property Enforcement
IPR	Intellectual property rights
IRS	Internal Revenue Service
ITS	Intelligent Transportation Systems
JAIC	Joint Artificial Intelligence Center
JPO	Joint Program Office
KAIROS	Knowledge-directed Artificial Intelligence Reasoning Over Schemas
LGBT	Lesbian, gay, bisexual, transgender
MAARS	Modular Advanced Armed Robotic System

MAD	Mutual Assured Destruction
MOD	Mobility on Demand
MRI	Magnetic resonance imaging
NGO	Non-governmental organizations
NHTSA	National Highway Traffic Safety Administration
NIST	National Institute of Standards and Technology
NLP	Natural language progressing
NSA	National Security Agency
NSF	National Science Foundation
NSPM	National Security Presidential Memorandum
NSTC	National Science Technology Council
NTIA	National Telecommunications and Information Administration
NTM	Neural Touring Machine
OECD	Organization for Economic Cooperation and Development
OIG	Office of Inspector General
OSTP	Office of Science and Technology Policy
QIS	Quantum information science
R&D	Research and development
RAS	Robotic and Autonomous Systems
RPI	Rensselaer Polytechnic Institute
SEC	Securities and Exchange Commission
SIPRI	Stockholm International Peace Research Institute
SNAP	Supplemental Nutrition Assistance Program
SPARC	Scholarly Publishing and Academic Resources Coalition
SPOT	Screening of Passengers by Observation Techniques
SRA	Sentencing Reform Act
STEM	Science, Technology, Engineering and Mathematics
TANF	Temporary Assistance for Needy Families
TRIPS	Trade-Related Aspects of Intellectual-Property Rights
U.K.	United Kingdom
U.N.	United Nations
UAE	United Arab Emirates
UAS	Unmanned aircraft systems
UNESCO	United Nations Economic and Social Council
UNU	United Nations University
USPTO	United States Patent and Trademark Office
WIPO	World Intellectual Property Organization
WTO	World Trade Organization

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SEC v. Wealthfront Advisers LLC, 3-18949 (Sec. Exch. Com. 2018)

State v. Loomis, 881 N.W.2d 749 (Wis. 2017)

USA v. InModi Pte Ltd., 3:16-cv-3474 (N.D. Ca. June 22, 2017)

Part I

**Artificial Intelligence: Disruption,
Application, and U.S. Policies**



1

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

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.

¹Jacob 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

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

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

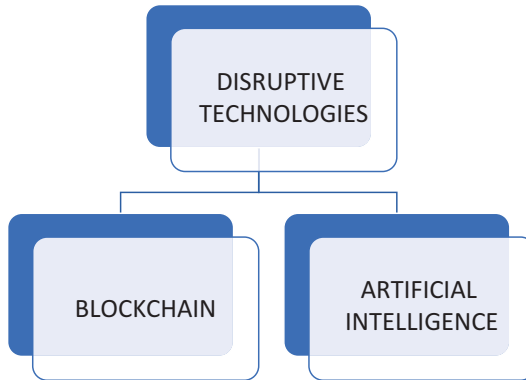


Fig. 1.1 Major disruptive technologies

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

⁶Martin 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

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/>.

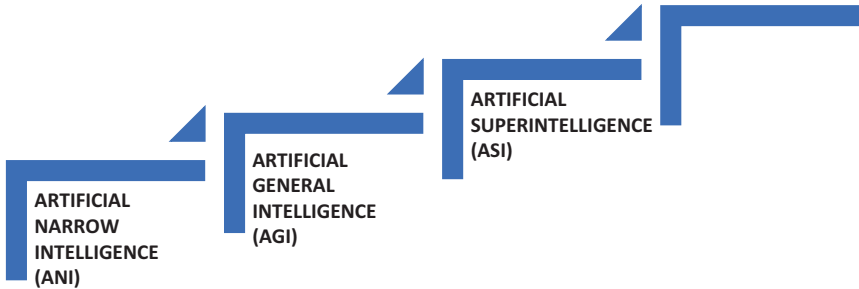


Fig. 1.2 Types of artificial intelligence

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

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

¹⁹*Id.* at 162.

²⁰Aaron 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.

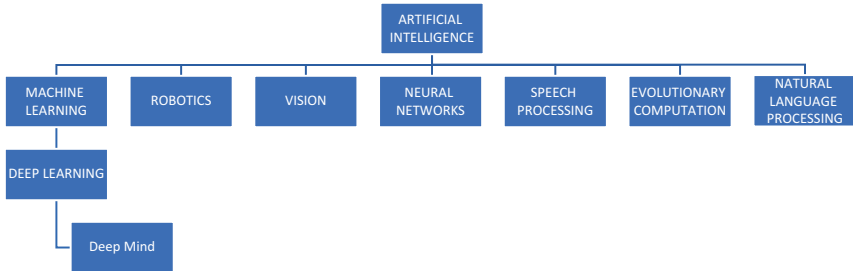


Fig. 1.3 AI partial subfields

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

²³Yasir 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 algorithms²⁷ 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

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/louiscolombus/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 Mustafa 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 able 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.

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/>.