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3 Artificial Intelligence: Already in Libraries?

Abstract: This chapter explores ideas of technical development through four industrial revolutions. Current innovations in communication and computing have led to ubiquitous computing, robots and artificial intelligence (AI). While the term AI was introduced in the mid-20th century, its ideas build on the developments in logic, mathematics, engineering and philosophy from antiquity to the present. Major subfields of AI include machine learning (ML), neural networks, computer vision, speech recognition, and natural language processing (NLP). AI is expected to disrupt the traditional professions as they are currently known. Fears are raised regarding job insecurity, along with AI biases and risks. Governments and international organisations are seeking to assist the progress of a human-centric AI by developing ethical standards. What are the current uses of AI and robots in libraries? How will they impact the profession of librarianship? Libraries promote innovation in their services because they are traditionally user-oriented but must share the risk and cost of AI projects to be effective. Most importantly, libraries must invest in new skills and knowledge to ensure competent librarians for the future.

Keywords: Robots; Artificial intelligence – Library applications; Fourth industrial revolution

Four Industrial Revolutions

Human development has striven to understand nature's forces and increase its chances for survival and consequently involved itself in scientific research and the application and implementation of technological results to ensure ongoing adaptation to new circumstances. The term Industrial Revolution (IR) was first used by Arnold Toynbee (1852–1883) to describe Britain's economic development from 1760 to 1840, but later applied more broadly to describe the process of economic transformation (Britannica 2023). The last two and a half centuries have witnessed four industrial revolutions. The first IR was powered by steam and water and transformed society from an agrarian society to an industrial one. The steam engine developed by James Watt was introduced commercially in 1776 and succeeded in the early 1800s by the steam-powered locomotive of Richard Trevithick. Steam-powered ships began to transport freight across the Atlantic and locomotives connected Britain's industrial hubs.

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The second IR (1870–1914) was powered by oil and steel and witnessed the invention of the telephone, light bulb and internal combustion engines by Nicolaus Otto in 1864 and Rudolf Diesel in 1892. Electrical power was also introduced leading to industrialisation, standardisation and mass production.

The third IR or digital revolution began in the latter part of the 20th century, was, and continues to be, marked by the developments in electronics, and information and communication technologies (ICT). Society has witnessed the development of ubiquitous computing as predicted by the now famous Moore's law stating that the number of transistors on a microchip doubles about every two years. This so-called exponential growth enables the computer power to also double and allows the miniaturisation of computing devices. Some famous predictions about the future of computing have failed to eventuate, like the one by IBM's early President, Thomas J. Watson, who allegedly said in 1943: "I think there is a world market for maybe five computers".

The fourth IR combines the physical, digital and biological worlds, enabled by quantum computing, genetic engineering, robots, cyber-physical systems and artificial intelligence (AI) (Schwab 2016). Is society on the verge of the 4IR or has it already started?

What is Artificial Intelligence?

Although the term artificial intelligence (AI) was introduced in the mid-20th century, the pillars of the concept were erected throughout many earlier centuries. Out of the *pléiade* of philosophers and scientists over time, one whose earlier contributions were crucial, was the Greek philosopher Aristotle (384–322 BC) who developed in his *Analytica Priora* the first principles of reaching a conclusion from a set of premises, guided by rules known as syllogisms (Aristotle 350BC). A syllogism is a logical argument based on two propositions or premises which if assumed to be true lead to a conclusion. A familiar example of a syllogism is:

- All humans are mortal
- All Greeks are humans
- Therefore all Greeks are mortal.

To be mortal belongs to all human beings; to be a human being belongs to all Greeks; therefore, to be mortal belongs to all Greeks. Aristotle was the founder of formal logic, which is widely used in academic discourse, IT and AI. The If-Then principle, is the core of computer programming and loops.

Key scientists related to developing AI include Alan Turing, John McCarthy and Douglas Hofstadter. Alan Turing (1912 – 1954) was an English mathematician and computer scientist, widely considered the father of theoretical computer science and AI. As a cryptologist he broke the code of the German Nazi Enigma machine in 1939. In 1950 Turing addressed the differences between human and machine intelligence and developed a standard test for a machine to be called intelligent. A computer could be said to think if a human interrogator asked questions of both a computer and a human and could not differentiate between the answers provided.

John McCarthy (1927 – 2011) was an American computer and cognitive scientist. In 1955 McCarthy along with Marvin Minsky, Nathaniel Rochester, and Claude Shannon drew up the Dartmouth Workshop proposal to the Rockefeller Foundation. For the workshop he envisioned "a 2-month, 10-man study of artificial intelligence" (McCarthy et al. 1955, 2). The six-week workshop took place at Dartmouth College in Hanover, New Hampshire in 1956 and became a seminal event. The most remarkable result of the Dartmouth proposal was the successful adaptation of the term "artificial intelligence" with its origins in an engineering discipline whose relationship to biological organisms is mostly metaphorical and inspirational. Even now, there is an ongoing debate about whether machines can think or just simulate thinking.

Douglas Hofstadter (1945–) is an American cognitive scientist. In 1977 at Indiana University, he launched a program called "artificial intelligence research", but later renamed it to "cognitive science research". Even though Hofstadter stated that he had no interest in computers, his extraordinary work inspired many students to start careers in AI (Hofstadter 1979, 2007).

Definitions of Artificial Intelligence

Numerous definitions exist to capture the meaning of AI. According to McCarthy and his colleagues in the Dartmouth proposal "…the artificial intelligence problem is taken to be that of making a machine behave in ways that would be called intelligent if a human were so behaving" (McCarthy et al.1955, 11). Half a century later, McCarthy defined AI as "the science and engineering of making intelligent machines, especially intelligent computer programs. It is related to the similar task of using computers to understand human intelligence, but AI does not have to confine itself to methods that are biologically observable" (McCarthy 2007).

But how can intelligence be defined? McCarthy added to his definition of AI "Intelligence is the computational part of the ability to achieve goals in the world. Varying kinds and degrees of intelligence occur in people, many animals and some

machines" (McCarthy 2007). Debates are ongoing about the most appropriate definition of human intelligence. Highly advanced machines like Deep Blue and others beat humans in chess, and games like Jeopardy or Go. Are the machines intelligent, or just fast processors? Such machines possess enormous datasets and simulate mental activity but are they really thinking?

Some writers like Ray Kurzweil and Nick Bostrom have predicted that computers will surpass human intelligence before the end of this century. Kurzweil uses the term "singularity" (Kurzweil 2005), while Bostrom calls the phenomenon "superintelligence" (Bostrom 2014). Other researchers are more sceptical. Hubert Dreyfus ridicules the claims of "progress" in human cognitive processes as a "displacement toward the ultimate goal" saying: "According to this definition the first man to climb a tree could claim tangible progress toward reaching the moon" (Dreyfus 1972, 12). Jerry Kaplan argues that the term artificial intelligence itself is misleading and creates unfounded expectations and misconceptions. Kaplan provocatively asks what would have happened if airplanes were called "artificial birds" (Kaplan 2016, 16). Such a nomenclature would "spark philosophical debates as to whether airplanes can really be said 'to fly' as birds do, or merely simulate flying". Interestingly, a great scientist and a great innovator of the 21st century voiced caution towards artificial intelligence exceeding human intelligence. Stephen Hawking said at the Web Summit conference in Lisbon in 2017: "Success in creating effective AI, could be the biggest event in the history of our civilization, or the worst" (Molina 2017). Elon Musk said in 2014 that AI is probably our biggest existential threat and with it "we are summoning the demon" (McFarland 2014).

Subfields of Artificial Intelligence

Dreyfus defined the following four areas of AI: game playing, language translating, problem solving and pattern recognition (Dreyfus 1972, xxxiii). Over fifty years after this segmentation of AI, numerous subfields have emerged. One researcher listed 87 of them. The following list is much shorter but contains the main subfields: machine learning (ML) and its branch artificial neural networks (ANN), computer vision (CV), speech recognition, natural language processing (NLP), and robotics.

ML is the science of training a device or software to perform tasks. Its capabilities may be fine-tuned by feeding in more data, so that it can learn over time. ML is used in libraries for automated indexing of documents against a controlled vocabulary or a thesaurus. The process can involve the use of ANN and deep learning. ANN is a computer program inspired by principles of a real neural network, such as the human brain. ANN consists of nodes connected by edges, which model the neurons

and synapses in a brain. Signals travel through the layers of the nodes and produce an output prediction. Deep learning is used in areas ranging from autonomous cars to robotics.

Computer vision (CV) is the process of analysing visual images, so that computers can read the imagery and see. When a Google search for images is conducted, the search engine algorithms search the metadata associated with the images, but the development of CV changes the process. The computer can process, for example, flat two-dimensional images of a scene from different angles and reconstruct a three-dimensional model. CV can be used to analyse sound because the sound chart is also a visual image.

Speech recognition or speech-to-text is a "capability which enables a program to process human speech into a written format" (IBM n.d.). Analysing and transcribing speech faces different problems, like separating signal from noise. As many discover when learning a new language and listening to native speakers, there is no obvious break between words. The flow or signal is continuous, and the intonation of the speaker can change the meaning completely. The tools performing speech recognition need a period of training to adjust to the voice of the user before becoming operative.

An early approach characteristic of NLP focused on codifying word categories and syntax. It was not fully successful because many exceptions exist in any language. NLP moved on to the use of statistical machine learning methods. For example, Google Translate, Trados and DeepL Translator build on big data files containing the official translations of documents which codify and confirm existing rules and practices combined with maintaining flexibility for learning. Translating is but one example of the use of NLP. NLP is used for indexing, creating summaries and answering questions. Chat GPT provides all these services and can even create a presentation with one's own voice. Time is the most expensive commodity and saving it creates a niche for NLP.

Robotics is a large subfield of AI. Multiple types of robots have been developed ranging from pre-programmed to humanoid to autonomous, teleoperated and augmented. Pre-programmed robots operate based on a predetermined set of instructions or programming. They follow a specific sequence of actions and are suitable for repetitive tasks, for example, on manufacturing assembly lines. Autonomous robots have the ability to operate and make decisions without continuous human intervention. They use sensors, algorithms, and artificial intelligence to navigate and perform tasks independently. Examples include self-driving cars, drones, robotic vacuum cleaners, and radio frequency identification (RFID) inventory robots. Humanoid robots are designed to resemble and mimic human movements and characteristics. They typically have a human-like appearance with arms,

legs, and a head. Humanoid robots are developed for various purposes, including research, assistance to elderly people, and even companionship.

Teleoperated robots are controlled by a human operator from a remote location. These robots receive commands from a human, usually through a controller or a computer interface, and perform tasks in environments that may be hazardous or difficult for humans to access directly. This type of robot is commonly used in fields such as bomb disposal, space exploration, and underwater exploration. Augmented robots are equipped with additional technologies or capabilities to enhance their performance. The additions might include sensors, cameras, or other tools to improve their perception abilities, decision-making processes, or overall functionality.

The integration of AI into the field of art has led to innovative and intriguing creations with many questioning the results. Many services are now available for the creation of music (McFarland 2024), but when a song for Luxembourg's National Day in 2017 was composed by AI , it was novel but provoked serious discontent among the composers (Huberty 2017). AI algorithms on systems like DALL-E2 can be used to create visually stunning and abstract artworks although many ask what it means for creativity (Clarke 2022).

The Future of the Professions

Machines have made human life more secure and comfortable throughout the various industrial revolutions. The changes and improvements have however also seen a parallel trend of creating fear and job insecurity. The beginning of the 19th century saw for example the emergence of the Luddites in England, a group of textile workers who sought to destroy the machines in their industry which they perceived were replacing skilled workers. With the vast implementation of robots and AI, fears of loss and change are revived on a new scale. Richard Susskind (1961–), a British author and professor specialising in legal technology, predicts in a book, co-authored with his son, Daniel, *The Future of the Professions,* the decline of the professions as they are currently known (Susskind and Susskind 2015). The book refers to an article of Julian Baggini on the changes wrought by new technology on the role of the barista in Italy. The traditional skilled task of blending and serving coffee was fundamentally altered with the introduction of coffee machines and capsules containing special coffee blends. "Baristas were talented artisans in a richly human process…baristas themselves also lament the loss of their craft" (Susskind and Susskind 2015, 324). While the introduction of coffee capsules was an innovative technology, it brought a disruption in the task of the barista.

"Disruptive innovation", a term introduced in the early 1990 by Clayton Christensen (1952–2020), is an innovation that makes products and services more accessible and affordable, however displacing established competitors (Clayton Christensen Institute n.d.). Disruptive technologies and services lead to the decline of some professions and create the need for new ones. The Susskinds reflected in 2015 on the professions of lawyers, teachers, tax advisors and consultants and argued that the traditional knowledge gatekeepers would gradually delegate some of their tasks to intelligent systems, first the repetitive tasks, but later more sophisticated ones. The prediction was that:

> … Increasingly capable systems will transform the work of professionals , giving birth to new ways of sharing practical expertise. In the long run… our professions will be dismantled incrementally (Susskind and Susskind 2015, 271).

While the book does not refer specifically to the profession of librarianship, a magnifying glass can be applied to reflect on the possibilities. Robots and AI will in the future be able to take decisions, even in a courtroom. Legal technologists are asking: "Is court a service or a place?" (Susskind 2019, 93) questioning whether people in dispute really need to congregate in physical court rooms to settle their differences. As libraries increasingly offer their resources and services online, the same question can be asked: Are libraries services or places? With the introduction of AI and robots, another reasonable question to put is whether the robot will assist the librarian or replace her. Asked that question in 2018, 89.47% of an international survey's respondents declared that they did not have such fears (Chakarova 2018, 100–104). Would a different answer emerge six years later in 2024?

Robots in Libraries

The International Federation of Robotics (IFR) distinguishes industrial and service robots and refers to the International Organization for Standardization (ISO) definitions:

> "Industrial robot" is an "automatically controlled, reprogrammable multipurpose manipulator, programmable in three or more axes, which can be either fixed in place or fixed to a mobile platform for use in automation applications in an industrial environment" (ISO 8373:2021).
> "Service robot" is a "robot in personal use or professional use that performs useful tasks for humans or equipment" (ISO 8373-2021).

ISO has recently added a third category, "medical robot," which is also defined by ISO 8373:2021. The World Robotics Reports issued by IFR in 2023 stated that the stock of operational robots around the globe exceeded 3.9 million units in 2022 (IFR 2023a; IFR 2023b). However, sales of professional service robots marked an impressive 48% growth in 2022. Robots can perform the functions conducted by doctors, policemen, composers (Huberty 2017), people who care for the elderly, and can even build a museum of robotics (Archello 2022).

It is certain that AI and robotics will affect the profession of librarians as traditional custodians of knowledge. There are already numerous AI implementations in libraries, archives, and museums, namely in computer vision, NLP, robots that make RFID inventories, item delivery and storage, machine learning, search engines, indexing and many other areas. A new framework called STEP, Segmentation, Transition, Education and Performance, has been developed by a three-year research project to help staff make effective use of new technologies like AI. Once implemented, STEP assists leaders to segment tasks suitable for AI, transition tasks among work roles, educate staff about AI and evaluate performance to reflect learning and use of AI (Leonardi 2023).

Why do libraries delegate some tasks to machines or systems? Since the introduction of online catalogues, library holdings are discoverable 24/7. With the implementation of RFID based self-check lending systems, libraries can be open to users 24/7 with no need for librarians to be present. The readiness to delegate tasks to machines is motivated by professional dedication to serve users and constituencies better and to deliver continuous and seamless services. Is there a limit to this trend, or will librarians contribute to the annihilation of their own profession? Will librarians contribute to the disruptive process or allow libraries to be disrupted? Will librarians lead the process, contribute actively to developments, or be part of the collateral damage?

Artificial Intelligence and Ethics

AI raises concerns not only regarding the loss of jobs, but also concerns about biases and other ethical issues. International organisations, as well as national bodies, have defined the framework of AI development and ethical standards. In April 2019, the European Commission's High-Level Expert Group on AI presented *Ethics Guidelines for Trustworthy Artificial Intelligence*. According to the *Guidelines,* trustworthy AI should be:

(1) lawful – respecting all applicable laws and regulations
(2) ethical – respecting ethical principles and values

(3) robust – both from a technical perspective while taking into account its social environment (European Commission 2019).

To ensure a human-centric and ethical development of AI in Europe, the European Commission further submitted in April 2021 a proposal for AI regulation or the so-called *Artificial Intelligence Act* (European Commission 2021). The rules establish different levels of risk and prohibit AI systems which might have an unacceptable level of risk to people's safety. While the Council of the European Union (EU) approved a compromise version of the Act, discussion continued with various disagreements on the definitions of AI systems and autonomy. The EU Parliament and the EU Council finally agreed on a draft Regulation, or the so-called AI Act in late 2023 (Council of the European Union 2023). The AI Act, published in the Official Journal of the EU on June 13, 2024, builds on the high-risk classification, to ensure that AI systems on the European market are not likely to cause serious fundamental rights violations or other significant risks (European Union 2024).

UNESCO adopted a Recommendation on the Ethics of AI in November 2021 to contribute to the international regulatory framework seeking to achieve human-centred AI (UNESCO 2021). Italy launched in November 2021 its strategic programme on AI for 2022–2024, aiming to develop a global hub of AI research and innovation within Italy (Italian Government 2021).

Conclusion

The last few years have witnessed a number of AI implementations in libraries. However, the process is not only costly, but also involves many iterations in project development accompanied by the risk of error and failure. It is necessary to work with others, combine efforts and share the risk and the cost of library AI projects. Adopting the long view on the library and the profession and ensuring the library meets its mission in serving the information needs of its community require significant investment. The investment is not only in AI infrastructure and technology, but firstly and most importantly in the education and development of library staff to ensure successful implementation of AI. Librarians must begin to plant seeds in a field where they may never live to harvest the crop.

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