Commentary

Artificial Intelligence and Medical Innovation

Eng Chye Tan, [1] *BSc (Hons), MSc, PhD*

Artificial intelligence (AI) is considered to be at the cutting edge of the 4th Industrial Revolution, and is part of a wave of technologies that will lead to the unprecedented fusion of the physical, digital and biological realms. As a result of the convergence brought about by technologies such as AI, biomedical engineering, robotics and nanotechnology, every facet of human society from health to industry, living environments and education is expected to be reshaped in the decades ahead. That being said, there is a need to balance its potential and impact against rising concerns such as transparency, privacy and human-centric decision-making.

AI and Healthcare

Healthcare is identified as one of the fields that will be profoundly impacted by AI. One of the reasons given is the exponential rate of growth in medical data. In 2013, 153 exabytes of healthcare data were generated. This number is estimated to hit 2314 exabytes in the year 2020, a projected rate of growth of 48% a year (1 exabyte is equivalent to 1 billion gigabytes, or 5 times the data of all printed materials in the world!).[1]

Other key drivers for the adoption of AI in healthcare include a rapidly ageing population, surge in chronic diseases in developed and developing countries, growing demand for skills and manpower in the health sector and the need to control spiralling health costs.

AI Gains Global Attention

The term "Artificial Intelligence" was coined by John McCarthy, a computer scientist, in 1956[2] and the associated term "Machine Learning" was introduced by Arthur Samuel in 1959.[3]

For many years, AI and self-learning machines remained within the speculative realm of science fiction. AI first emerged into the public consciousness in 1996 after former world chess champion, Garry Kasparov, was beaten in 1 of 6 games by the chess-playing computer—Deep Blue—developed by IBM, and again in 1997. In 2015, AI gained global attention after AlphaGo, a computer application developed by Google to play the board game Go, emerged victorious against a human Go champion. Compared to chess, it was widely thought that Go would be too difficult for a computer to master. With these victories, the world finally woke up to the astonishing power and sophistication that AI technologies have to offer.

Both events, which took place 2 decades apart from one another, also demonstrated the rapid pace of technological advancement in AI. Deep Blue was a purpose-built computer that achieved its winning feat through a combination of clever algorithms and brute-force computing power.[4] It was capable of performing 200 million moves a second, or 36 billion positions in 3 minutes, which was the time allocated for a single move to be made under chess tournament conditions.

In 2016, AlphaGo deployed AI at a higher level of sophistication. Unlike Deep Blue, AlphaGo employed learning or—in technical jargon—deep learning. After being fed with 30 million Go moves, it could play against itself and build its own databank of knowledge and experience, thereby learning and enriching that databank. Computing power and the advent of more effective algorithms made AlphaGo different from Deep Blue. Its core technology was the use of artificial neural networks (or sophisticated algorithms) to perform deep learning. Deep learning is a subset of machine learning, where neural networks learn from large amounts of data and try to emulate how the human brain learns from experience. The design of neural networks was loosely modelled after the human brain and its processes, which typically consists of millions of interconnected neurons communicating and transmitting information to one another.[5]

Before AlphaGo, it was thought that AI would not be able to master the board game Go; in fact, after Deep Blue's victory in 1997, it was thought that it would be another 100 years before a computer could play Go at a sufficiently high level.[6]

[1]Office of the President, National University of Singapore, Singapore
Address for Correspondence: Prof Tan Eng Chye, Office of the President, National University of Singapore, 21 Lower Kent Ridge Rd, Singapore 11907.
Email: uprsec@nus.edu.sg

AI: The New "OS" for Healthcare

Today, AI is used in diverse industries ranging from online commerce to logistics, traffic management and weather forecasting. In healthcare, AI is viewed as a key enabling technology that can unleash new models of care across primary, secondary and tertiary levels. The projected role of AI in healthcare has become so central that it has since been described as the new "OS" in healthcare of the future.[7]

A key strength of AI is in pattern recognition and detection, particularly seen in the fields of radiology[8] and ophthalmology.[9] Promising trials have been conducted—including those in Singapore[10]—where AI and machine learning were used to detect and diagnose a wide range of diseases and conditions from cancers to brain injuries, chronic illnesses and even depression. In some cases, the AI rate of accuracy matched—and possibly surpassed—that of human experts.[11]

Another strength of AI is that of predictive analytics. AI can scan vast amounts of biomedical, clinical and patient data and information to identify subjects who have a family history of hereditary diseases or those at increased risk of a chronic disease.[12] Predictive analytics can trigger early intervention, which can then be paired with personalised care. With improved processing time, there is greater optimisation of resources and better load capacity management in a healthcare system.[13]

AI and robotics complement each other highly, and the results are applications that range from robot-assisted surgery to care solutions for the elderly. The Japanese conglomerate, Sony, recently launched a robotic dog, Aibo, that was equipped with cameras, artificial intelligence and Internet connectivity. Aibo can be used to monitor the elderly, children and even pets.[14] AI and robotics could well become the transformative key that can provide "caring in place" solutions for the growing elderly population. With the advent of fifth generation—or 5G—technologies, surgical procedures can even be performed by surgeons across locations.[15]

AI can also play a greater role in medical learning and training through the simulation of naturalistic scenarios, access to vast databases on cases and conditions and customisable learning situations based on active, real-time feedback.[15]

Researchers are also exploring the possibilities and potential of AI at the microscopic and even nano levels. Smart biosensors are envisaged to be powered by AI that are capable of taking highly accurate medical images and to provide live feeds of compounds and chemicals traversing through the human body. Other possibilities include the use of micro-scale bio-vehicles in drug administration that provide precise targeting of locations in the required dosages.[16–8]

Strengths and Limitations of AI

Although AI is expected to play a central role in future, it is important to have a balanced view of its strengths and limitations. With this understanding, there can be better appreciation of the critical role that human decisions will continue to play even as healthcare and other sectors increasingly utilise and deploy AI in various roles and functions.

A major advantage of AI is that it can process and analyse information on an unprecedented scale and speed. The computational, quantitative and analytical capabilities of AI have surged beyond the threshold of human abilities. AI can plough through enormous troves of data—past and present—from multiple sources in the search for a solution. AI also excels at spotting patterns and anomalies and can flag them for further study or to generate new ideas.

Unlike humans, AI does not suffer from decision fatigue. Consequently, this improves speed and accuracy in decision-making[19] that can prove to be vital in situations such as time-sensitive healthcare diagnosis. These are the powerful advantages of AI, but there are also significant shortfalls and blind spots in current AI technology.

A major roadblock to the adoption of AI in healthcare is the issue of the "black box" problem. Because of its self-adjusting algorithms and statistical weighing computations, AI is not able to explain—in a transparent manner—how a decision or option was derived. In healthcare, the relationship of trust between patients and healthcare professionals is of paramount importance, and this is maintained and supported by exacting standards of accountability and transparency.

Another limitation of AI is the need to ensure that the data and information fed into an AI engine is free from bias or defect. When the datasets are flawed or when its programmes or algorithms contain biases or filters that skew results or outcomes, the reinforcing and compounding nature of AI will magnify these defects—and perhaps exponentially—over time.

Finally, AI still lacks the unique cognitive capabilities of humans, such as the ability to generalise or abstract relationships from limited data or to transfer insights and knowledge from one domain to another. In the field of linguistics, AI also struggles to define symbols, concepts and their associative meanings (such as the

meaning of puppy love) although intense research is ongoing to address this issue.

Humans and AI: a Synergistic Pairing

With a fuller understanding of the capabilities and limitations of AI, one can then turn to a consideration of how the power of AI can be harnessed to synergise with the unique attributes of humans.

Many decisions are made when there is imperfect information, uncertainty and unpredictability. Under these circumstances, an intuitive or "gut decision" approach is often used. Although widely described as lacking rationality, a more accurate description of this approach would be decision-making that is based on a blend of imagination, sensitivity, experience, extrapolation and judgement. It is about analysing and understanding the situation at a deeper level of perception and looking at the world with an "abstracted and holistic view".[20] It is a very unique human ability.

Another aspect of human decision-making involves dealing with "equivocality". Put simply, in complex scenarios, interested parties who have different agendas and interests may differ considerably in their interpretations of decisions.[20] Human actors must negotiate diverse—and sometimes conflicting—needs, and this requires deep social intelligence and sensitivity to both formal and informal contexts to build a common ground.

Leadership is another human activity that operates at both formal and informal levels. Leadership is often a synthesis of analytic rigour, creative and original thinking and social and emotional intelligence. While AI can be used as a powerful tool to analyse data and patterns, the future rarely unfolds according to strictly prescriptive and rational terms; instead, leaders must provide context, empathy and an integrated, holistic perspective even as their organisations adapt to changing circumstances.

New Competencies and Evolving Roles

For an AI-human symbiosis to achieve its full impact, several approaches can be adopted. The first approach is to raise AI literacy and competency across the board throughout an organisation. A foundational understanding of how AI technologies work will facilitate informed discussion on how AI can be integrated into individual and organisational processes and requirements. AI literacy will also increase confidence and reduce anxiety in adapting to—and exploring—new possibilities as technologies advance.

Another major area concerns the redesign or reimagination of roles, scope and processes in the workplace that involves 2 components: distinguishing and harmonising the complementary capabilities of human intelligence and AI. Just as a greater understanding of AI technologies can sharpen the analytical skills of human agents, AI can enhance its utility through greater interaction and feedback from more human interactions. For example, an interdisciplinary team that harnessed the power of CURATE.AI—an AI platform—was able to continuously identify the optimal doses of a drug treatment programme for the successful treatment of cancer and other diseases.[21,22]

The second approach is closely related to the enhancement of human attributes such as holistic thinking, emotional intelligence and imaginative problem-solving. When their capabilities in these areas are strengthened, human actors will be better placed to reap greater synergy and positive outcomes from their partnership with AI.

The third approach is to relook current data framework. Data is now a new "resource", and it is a particularly important one in AI. Data is the "input" that is needed to drive AI. When the data is corrupted, the outcomes from AI would be affected. This is a manifestation of the "garbage in and garbage out" syndrome. Thus, it is important to maintain data collation and integrity.

Finally, AI is a powerful technology and efforts must be made to ensure that it is beneficently harvested for human benefit. Recently, Singapore has articulated her AI Governance Framework[23] which is a forward-looking and human-centric model that stresses technological advancement for the benefit of society and allows adaptability and flexibility as the AI landscape continues to evolve.

Ultimately, AI is a tool and a technology. It is also one of the most powerful inventions created by humans. In coming years, its transformative potential will undoubtedly reshape critical sectors such as healthcare. However, humans will still retain the autonomy—and responsibility—to ensure its fair and justifiable use to address human challenges and improve the well-being of society.

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