Artificial Intelligence and Healthcare

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I. What is Artificial Intelligence?

Artificial intelligence ("AI") is the catch-all name for machine learning, deep learning and robotics. As such, it is a bit of a misnomer – AI isn't a system, it is a tool implemented in a system. At its core, AI is a tool that strives to mimic human brain power and decision-making processes by the initial creation of algorithms that learn from themselves and that continue to learn from their own experience – much like humans. This allows the system (powered by AI) to harness that experience in order to do certain tasks better, faster or more efficiently than humans.

> **Machine learning** is an AI application whereby the system uses an iterative process until it "learns" based on past experience. An example could be an application that processes similar data repeatedly until it can predict an answer – a Google search bar suggesting the words to complete a search request is an example of this.
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> **Deep learning** is a more complex form of AI whereby the system is fed large amounts of data until it "learns" by example; deep learning is inspired by the human neural network, allowing the system to discover patterns – face recognition software and self-driving cars are examples of this.
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> **Robotics** is a machine performing a human task, usually with accuracy and precision beyond what a human is capable of – a new generation Roomba vacuum is an example of this.

Much like humans, AI thrives on and improves with experience. In the case of AI-driven systems, experience equates to more and more data, more passes through the data and more neural connectivity. An easy human analogy is a parent keeping a child from touching a hot stove. The parent will do that repeatedly, until the child knows not to touch the hot stove (akin to machine learning); eventually, the child will know through experience and neural connectivity that hot things of any kind will hurt and, without being told by a parent, will know not to touch an open flame, metal under a summer sun, etc. (akin to deep learning).

To some extent, *what* AI is has ceased to be important to most users – the vast majority of Americans (85% of us, as of 2017) report using at least one AI device, such as navigation

apps, Alexa/Siri, streaming devices, etc.[1] But while we accept, even embrace, AI in our personal/consumer lives, the adoption rate in healthcare has been slower; a 2017 survey pegged its use by healthcare systems at less than 50%.[2] (Interestingly, though, an international 2018 survey of pathologists indicated nearly 75% reported being "interested or excited in AI as a diagnostic tool"[3]).

II. AI and Healthcare

While the specifics of the different flavors of AI may be of interest to techies, whether a system uses deep learning, machine learning or robotics is a distinction without much of a difference for our purposes here. The potential promise and the potential pitfalls of AI, however, cut across all perspectives, particularly in healthcare. Its supporters paint a picture of freedom from tedium, increased efficiencies, reduced costs and better patient care. Its detractors warn against loss of the "human touch", inherent biases in the data and robots run amuck. The truth is likely somewhere in the middle and represents the benefit of technology in general – it makes processes routine (boring, even), creating space for people to spend their time, energy and brainpower on other matters. Whether or not AI enables healthcare to achieve the Holy Grail trifecta of better individual patient experience, better population health and lower costs is anybody's guess.

AI applications in healthcare garner tremendous interest, and the investment sector has taken note: AI in healthcare is an investment favorite, about $1 billion was invested in healthcare AI in recent years;[4] the AI health market is forecast to hit $6.6 billion by 2021 – eleven times the size of the market in 2014.[5] According to consulting giant Accenture, the top 5 AI healthcare applications (in terms of "estimated potential annual benefits…by 2026") are: Orthopedic Robot-Assisted Surgery, Virtual Nursing Assistants, Administrative Workflow Assistance, Fraud Detection and Dosage Error Reduction. Connected machines, clinical trial participant identifier, preliminary diagnosis, automated image diagnosis and cybersecurity round out the top 10.[6]

The top AI application, according to Accenture, is robot-assisted surgery. "Cognitive robotics can integrate information from pre-op medical records with real-time operating metrics to physically guide and enhance the physician's instrument precision. *The technology incorporates data from actual surgical experiences to inform new, improved*

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[1] https://news.gallup.com/poll/228497/americans-already-using-artificial-intelligence-products.aspx, March 6, 2018

[2] https://www.hcinnovationgroup.com/population-health-management/news/13029301/survey-broad-usage-of-ai-in-healthcare-still-two-to-five-years-out, Oct. 13, 2017

[3] Physician perspectives on integration of artificial intelligence into diagnostic pathology, *Nature,* https://www.nature.com/articles/s41746-019-0106-0, published online April 26, 2019

[4] General Electric Company, *AI in Healthcare: Keys to a Smarter Future*, https://www.gehealthcare.com/-/media/b3a5e32538454cf4a61a4c58bd775415.pdf, 2018

[5] Accenture, *Artificial Intelligence: Healthcare's New Nervous System,* https://www.accenture.com/us-en/insight-artificial-intelligence-healthcare, 2017,

[6] *Ibid*.

techniques and insights."[7] Accenture goes on to estimate that workflow assistants (*e.g.,* voice-to-text functionality) can reduce physician paperwork time by 17% and nurse paperwork time by 51%.[8]

While investment interest is broad across all AI healthcare applications, the applications currently in use, or for which there is great academic and research interest, involve particularly radiology and pathology, and those around workflows and population health. In other words, applications that can augment human activity by doing the tedious tasks (such as reviewing thousands, if not millions, of slides in order to find the small percentage indicating a potential health problem) or by relieving clinicians of non-clinical tasks, or determining risk factors, are the ones currently in use the most. Some examples:

- *Screening for diabetic retinopathy* (received FDA approval in 2018 and already in the market): an image of the patient's retina is uploaded to the software system in the cloud, the system reviews the scan and returns a result of either 'More than mild diabetic retinopathy detected: refer to an eye care professional' or 'negative for more than mild diabetic retinopathy; rescreen in 12 months.'[9]

- *Post-partum depression in developing regions* (pilot study in Kenya): a study to see if live and automated text messaging augmented by AI could deliver care to a country in which mental health providers are very scarce.[10]

- *Predicting adverse health events in individual patients* (system under development by Penn Medicine and University of Pennsylvania): algorithms that can predict in-surgical and post-discharge complications in individual patients; already developed are algorithms that detect heart failure and sepsis at their earliest stages.[11]

- *Virtual nursing assistants* (currently on the market): nurse avatars answer questions 24x7, automate data collection, and generally free up human nurses to perform clinical tasks rather than administrative tasks.[12,13]

- *Workflow applications* (many are currently on the market): applications that automate administrative workflow tasks to allow clinicians to save time. These applications can include voice-to-text transcriptions for charting, prescriptions and test orders, and computer assisted physician documentation programs. Cleveland Clinic enjoys a more sophisticated application, using IBM's Watson and big data to create an individual's

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[7] *Ibid.* Emphasis added.
[8] *Ibid*.
[9] https://www.aao.org/headline/first-ai-screen-diabetic-retinopathy-approved-by-fda, April 12, 2018
[10] https://www.healthcareitnews.com/ai-powered-healthcare/ai-tapped-alleviate-postpartum-depression-developing-regions, May 2, 2019
[11] Big Data, Analytics & Artificial Intelligence, General Electric Company, http://newsroom.gehealthcare.com/wp-content/uploads/2016/12/GE-Healthcare-White-Paper_FINAL.pdf, 2016
[12] https://venturebeat.com/2018/04/22/the-3-most-valuable-applications-of-ai-in-health-care/, April 22, 2018
[13] https://www.healthcareitnews.com/ai-powered-healthcare/how-ai-helping-struggling-hospital-systems, April 30, 2019

treatment plan; "Watson's natural language processing capabilities allow care providers to quickly and accurately analyze thousands of medical papers to provide improved patient care and reduce operational costs."[14]

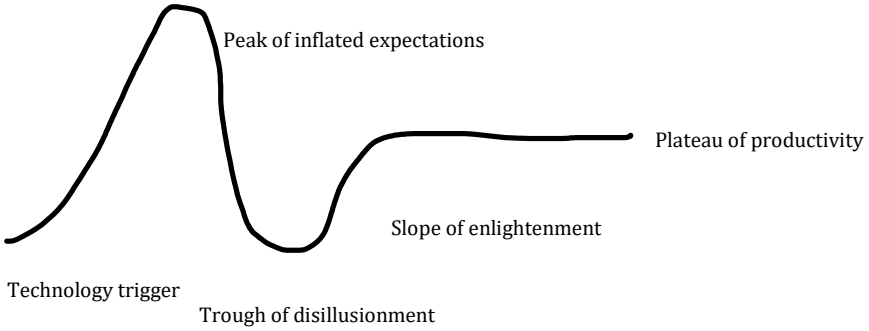
- *Mission control command centers* (*e.g.,* Humber River Hospital and Johns Hopkins Hospital): Johns Hopkins Hospital created a command center powered by AI technology for predictive analytics; it helps command center staff to know, among other things, how to reduce wait times by predicting room turns and patient discharges. Humber River Hospital in Toronto has gone even further by going all-digital, employing tracking devices on patients and staff to monitor and manage the flow of patient activity, using robots to prepare and deliver supplies and medications, and automating 75% of its non-clinical operations like pharmacy, laundry, and food delivery[15]. According to Humber River Hospital, which bills itself as the world's first all-digital hospital, the impact of its command center on patients and health care delivery systems "will be equivalent to adding 45 new beds, enabling us to serve 4,000 more patients per year."[16] Robots even add a "human touch" at Humber River Hospital:

> Pepper is child-sized with large, expressive eyes and a sweet voice. It greets visitors, provides directions, plays games, does yoga and even dances. Using facial recognition to detect human emotions, it adapts its behaviour according to the mood of the person with whom it's interacting. Pepper makes the Hospital an even more welcoming place for everyone it encounters.[17]

[14] https://venturebeat.com/2018/04/22/the-3-most-valuable-applications-of-ai-in-health-care/, April 22, 2018
[15] https://www.modernhealthcare.com/article/20160430/MAGAZINE/304309981/inside-north-america-s-first-all-digital-hospital, April 30, 2016
[16] Humber River Hospital website, https://www.hrhfoundation.ca/commandcentre/
[17] Humber River Hospital website, https://www.hrhfoundation.ca/blog/pepper/ ; *see also* https://www.newswire.ca/news-releases/humber-becomes-the-first-hospital-in-canada-to-recruit-a-humanoid-robot-674893273.html, Feb. 22, 2018

III. Opportunities and Challenges

The opportunities for AI in healthcare are intriguing. AI applications can do in seconds what humans might not be able to do at all, such as analyze a fantastical amount of data.[18] For those of us still struggling to get Siri to understand a request for the nearest gas station, the potential of AI seems surreal. Yet, AI is a technology with a lifecycle like any other – first there are very high expectations, then reality sets in, then the technology improves until it converges with realistic expectations. Gartner describes this as a five phase "Hype Cycle": first, a "technology trigger" that sets it off, then the "peak of inflated expectations", followed by a "trough of disillusionment", then a "slope of enlightenment" and finally, a "plateau of productivity". [19]



It is not yet clear if AI in healthcare is still at the "Peak of Inflated Expectations" or traveling up the "Slope of Enlightenment" (the trough of disillusionment seems to have been achieved in many cases). But what is clear is that in order to achieve even some of AI's expectations, there needs to be a clear alignment between what AI can do (relieve humans of certain tedious tasks and improve accuracy) and a user/healthcare entity's priorities. Otherwise, it is a solution in search of a problem.

The challenges are not insignificant, either. It's tempting to say humans will use AI's capabilities and analyses fully, wisely and appropriately, but who knows? Some challenges are specific to healthcare, such as providers who feel burned by EHRs and unwilling to embrace yet another new technology. Since there is not yet a robust universe of case studies around the outcomes of AI applications, there remain individuals who still question the value of them, and because AI projects are still very new, there are logistical difficulties

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[18] A vertical industry brief from consultant company EMC^2 and research company IDC provides this amazing statistic: 153 exabytes of global health data in 2013. An exabyte is one quintillion (10^{18}) bytes, or one billion gigabytes; all the words ever spoken by humans could be stored in 5 exabytes. See, https://www.emc.com/analyst-report/digital-universe-healthcare-vertical-report-ar.pdf. More recent estimates could not be found, but one can only assume the volume of data has grown since 2013. See also, https://en.wikipedia.org/wiki/Exabyte

[19] https://en.wikipedia.org/wiki/Hype_cycle

such as unrealistic timelines and an inability to calculate a return on investment. There are also cultural fears, such as losing the human touch.

And, of course, many (if not most) people don't understand how AI works, resulting in a belief that "Through 2020, 80% of AI projects will remain alchemy, run by wizards".[20]

> AI projects face unique obstacles due to their scope and popularity, misperceptions about their value, the nature of the data they touch and cultural concerns. To surmount these hurdles, CIOs should set realistic expectations, identify suitable use cases and create new organizational structures.[21]

Easy, right?

And we haven't even begun to discuss the data bias, privacy, security, legislation, regulation, liability, licensing and ownership challenges of AI in healthcare.

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[20] https://www.gartner.com/smarterwithgartner/gartner-top-strategic-predictions-for-2019-and-beyond/, Oct. 16, 2018.

[21] Whit Andrews, distinguished vice president analyst at Gartner, quoted in *The CIO's Guide to Artificial Intelligence,* https://www.gartner.com/smarterwithgartner/the-cios-guide-to-artificial-intelligence/, Feb. 5, 2019.