THE POTENTIAL FOR ARTIFICIAL INTELLIGENCE IN HEALTH CARE

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Abstract

The complexity and rise of data in healthcare means increasing use of artificial intelligence (AI) in the field. Several types of AI are already being used by payers and providers of care, and life sciences companies. The main types of applications include medical recommendations, patient interaction and care, and administrative tasks. Although there are many areas where AI can outperform humans in healthcare tasks, the difficulty in implementing it will prevent a large scale for a considerable period. There are also ethical issues to consider and discuss. This article discuss the ethical issues while considering the potential of artificial intelligence in health care.

KEYWORDS: Artificial intelligence, clinical decision support, electronic health record systems

Introduction

Artificial intelligence (AI) being increasingly prevalent in sectors like business and society, is now being used for health care too. AI technologies have the potential to transform patient care and the administrative processes governing healthcare within provider, payer and pharmaceutical organizations. Several studies point that the AI outperforming humans in crucial healthcare tasks, for instance in diagnosing diseases, research, spotting tumors etc. Despite this, the belief is that AI will not replace humans in healthcare anytime soon. This piece debates

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about of AI in healthcare and the obstacles to its implementation.

Types of AI relevant to Healthcare

Artificial intelligence (AI) is not one technology, but rather a collection of them, out of which most are important for healthcare. However the specific tasks they carry out differ greatly. Some particular AI technologies of high importance to healthcare are defined and described below.

Machine Learning – Neural Networks and Deep Learning

Machine learning is an application of AI which can function without instructions by using algorithms and statistical models to analyze and draw inferences from patterns in data. It is one of the most common forms of AI; employed by majority of companies according to survey done among 1100 US managers from different companies in the US.[1] It is a broad technique at the core of many approaches to AI and there are many versions of it. Machine learning has different forms based on its complexity.

The most common and least complex is precision medicine. It involves predicting what treatments are likely to succeed based on various patient attributes and the treatment context.[2] The great majority precision medicine applications require a training dataset (the initial data used to train the machine learning

[1] Deloitte Insights. State of AI in the enterprise. Deloitte, 2018. www2.deloitte.com/content/dam/insights/us/articles/4780_State- of-AI-in-the-enterprise/AICognitiveSurvey2018_Infographic.pdf.

[2] LeeSI,CelikS,LogsdonBA etal.Amachinelearningapproach to integrate big data for precision medicine in acute myeloid leukemia. Nat Commun 2018:9:42.

models) where the outcome variable (e.g. onset of disease) is known; this is called supervised learning.

A more complex form of machine learning is the neural network – a technology that is well established in healthcare research for several decades.[3] Neural network has been a remarkable machine learning AI technology for healthcare institutions. This weighs in inputs, outputs, and variables to predict whether a particular disease might be acquired by a patient in the future. It functions similar to human brain's neural process when it receives information. It is used for categorisation applications i.e. whether a patient will acquire particular diseases. According to the inputs, the networks will generate the best possible results.

The most complex forms of machine learning involves deep learning. This is neural network but with many layers which predict outcomes. It has been used in oncology and radiology for accurate diagnosis. There may be multiple hidden features in such models which can be uncovered faster due to today's technology. Deep learning is often used to recognise cancerous tissues in radiology.[4] It can recognise potentially cancerous lesions in radiological images and radiomics to detect clinically relevant data invisible to the naked eye. Deep learning has also been used for speech recognition. However, this type of learning is complex and beyond the interpretation of common human observers. Artificial intelligence (AI) being increasingly prevalent in sectors like business and society, is now being used for health care too. AI technologies have the potential to transform patient care and the administrative processes governing the healthcare sector. Several studies point out that AI outperforming humans in crucial healthcare task, for instance in diagnosing diseases, research, spotting tumors etc. Despite this, the belief is that AI will not replace humans in healthcare anytime soon. The article

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[3] Sordo M. Introduction to neural networks in healthcare. OpenClinical, 2002. www.openclinical.org/docs/int/neuralnetworks011.pdf

[4] Fakoor R, Ladhak F, Nazi A, Huber M. Using deep learning to enhance cancer diagnosis and classification. A conference presentation. The 30th International Conference on Machine Learning, 2013.

discusses the potential of AI use and the barriers to implementation.

Natural Language Processing

Understanding human language has been a key goal of AI researchers for a long time. This technology attempts to recognize human language to transcribe details and involves speech recognition, textual analysis, and translation. This is helpful in the healthcare domain for documentation, publication of research, analysis of unstructured clinical notes on patient diagnosis and care, preparation of notes, and transcription of patient interactions. NLP utilizes the following approaches – statistical and semantic. Statistical NLP incorporates deep learning neural networks to gain better accuracy in speech recognition.

Rule-based Expert Systems

These systems combine a series of rules in the pattern of "if-then" coding to provide information about a medical domain. This is employed in aiding clinical decisions and is in use today by several Electronic health record (EHR) providers.[5] While this system is effective and easy to understand, it is liable to breakdowns due to conflicts between a large number of rules. These rules are not consonant to the evolving knowledge in the medical field and editing them requires a lot of time. Thus, more effective machine learning algorithms are taking its place.

Physical Robots

Physical robots are well known by this point, given that more than 200,000 industrial robots are installed each year around

[5] Vial A, Stirling D, Field M et al. The role of deep learning and radiomic feature extraction in cancer-specific predictive modelling: A Review. Transl CancerRes2018;7:803–16.

the world. They perform pre-defined tasks like lifting, repositioning, but have increasingly become more collaborative and easy to train by humans. With other AI capabilities being fused into their 'brains' i.e. operating systems, they are becoming more intelligent. Due to increasing AI capabilities and human collaboration, surgical robots are being popularised to help surgeons in performing operations by enhancing their ability to see and create precise and minimal incisions, stitches, etc.[6] Though not involved in major medical decisions, these surgical robots are used for gynaecological surgery, prostate surgery, and head and neck surgeries.

Robotic Process Automation

This computer program conducts administrative tasks such authorisation, updating records and billing. Compared to other forms of AI they are cheap, easy to program and transparent in their actions. Robotic process automation (RPA) involves computer programs on servers. This technology combines workflow, business rules, and presentation layer with an information system to follow a set of rules to complete digital tasks. It can be combined with varied technologies such as image recognition to extract data from faxed images and transcribe digitally.[7] The combining will ensure more composite solutions in the future.

Diagnosis and Treatment Applications

Diagnosis AI has played an imperative role in the diagnosis and treatment of diseases since the 1970s but has seen severe implementation lacks in healthcare organisations. The development of MYCIN by Stanford for diagnosing blood-borne

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[6] Davenport TH, Glaser J. Just-in-time delivery comes to knowledge management. Harvard Business Review 2002. https://hbr.org/2002/07/just- in-time-delivery-comes-to-knowledge-management.

[7] Hussain A, Malik A, Halim MU, Ali AM. The use of robotics in surgery: a review. Int J Clin Pract 2014;68:1376–82.

bacterial infections was significant,[8] however, these rule-based systems were not entirely efficient and failed to integrate with clinical practice. IBM's Watson presented a more accurate system for precision medicine, especially for cancer treatment. This technology combined machine learning and NLP and included a set of cognitive services such as application programming interfaces, speech vision, and machine learning-based data analysis. However, Watson could not be a major facilitator in the healthcare market as teaching it new cancer diagnoses proved difficult,[9] and failed to compete with free open-source programs.[10] Watson is a set of cognitive functions and thus using it for cancer treatment was a very ambitious project. The implementation of AI in healthcare has stumped many even though such technologies are used even in the NHS.[11]The sustenance of these ruled-based systems in the organisations has been problematic as they are unable to handle the constantly evolving medical knowledge, especially genomic, proteomic, metabolic healthcare approaches. The technology for AI has seen improvement over the years, with advancement in techniques for radiology analysis,[12] retinal scanning,[13] or genomic-basedprecision medicine,[14] claiming higher accuracy than practitioners as they use statistics based on evidence and probability. But there are several ethical concerns for the

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[8] Bush J. How AI is taking the scut work out of health care. Harvard Business Review 2018. https://hbr.org/2018/03/how-ai-is-taking- the-scut-work-out-of-health-care.

[9] Buchanan BG, Shortliffe EH. Rule-based expert systems: The MYCIN experiments of the Stanford heuristic programming project. Reading: Addison Wesley, 1984.

[10] Ross C, Swetlitz I. IBM pitched its Watson supercomputer as a revolution in cancer care. It's nowhere close. Stat 2017. www.statnews.com/2017/09/05/watson-ibm-cancer.

[11] Davenport TH. The AI Advantage. Cambridge: MIT Press, 2018.

[12] Right Care Shared Decision Making Programme, Capita. Measuring shared decision making: A review of research evidence. NHS, 2012. www.england.nhs.uk/wp-content/uploads/2013/08/7sdm-report.pdf.

[13] LoriaK.PuttingtheAIinradiology.RadiologyToday2018;19:10. www.radiologytoday.net/archive/rt0118p10.shtml.

[14] Schmidt-ErfurthU,BogunovicH,SadeghipourAetal. Machine learning to analyze the prognostic value of current imaging biomarkers in neovascular age-related macular degeneration. Opthamology Retina 2018;2:24–30.

patient-clinician relationships.[15] Companies such as Google have collaborated with health delivery networks to create predictions models that warn about high-risk conditions such as heart failure.[16] Jvion has created a clinical success machine that accurately identifies high-risk patients and the relevant treatments. Certain firms such as Foundation Medicine have adopted diagnostic and treatment-centric approaches for cancer, based on genetic profiles, to identify cancer variants and the response to drug treatments. There has been increasing use of population health machine learning models by providers and payers for care as well to predict populations at risk of specific diseases,[17] accidents,[18] or decide on hospital readmissions.[19]

While these models are effective at predictions, they suffer from a variety of challenges. Most of the emerging technologies remain confined to research laboratories especially due to challenges in medical ethics and patient-clinician relations, leading to a lack of integration within the clinical workflow. Several AI technologies only address one issue, limiting the involvement in the care process. Population health-based models also do not consider factors such as the socio-economic status of patients, thereby providing a not wholly accurate picture.

Integration into clinical workflow and EHR systems, of AI, regardless of nature can be challenging. And it is such integration that is a great barrier of implementation of AI into

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[15] Aronson S, Rehm H. Building the foundation for genomic-based precision medicine. Nature 2015;526:336–42.

[16] Rysavy M. Evidence-based medicine: A science of uncertainty and an art of probability. Virtual Mentor 2013;15:4–8.

[17] Rajkomar A, Oren E, Chen K et al. Scalable and accurate deep learning with electronic health records. npj Digital Medicine 2018;1:18. www.nature.com/articles/s41746-018-0029-1.

[18] ShimabukuroD,BartonCW,FeldmanMD,MatarasoSJ,Das R. Effect of a machine learning-based severe sepsis prediction algorithm on patient survival and hospital length of stay: a randomised clinical trial. BMJ Open Respir Res 2017;4:e000234.

[19] Aicha AN, Englebienne G, van Schooten KS, Pijnappels M, Kröse B. Deep learning to predict falls in older adults based on daily-Life trunk accelerometry. Sensors 2018;18:1654.

healthcare. Some EHR vendors have begun limited use of AI,[20] but in their early stages. Therefore, substantial integration of AI into the healthcare system is necessary to develop an effective mechanism.

Patient engagement and adherence applications

Patient engagement and adherence has been the bridge between ineffective and good health outcomes. The more patients proactively participate to take care of their well-being, the better the outcomes in terms of utilisation, financial outcomes and member experience. With AI, these elements are being catered to. Providers and hospitals often use their clinical expertise to develop a treatment plan for chronic or acute patients' health. However if the patients do not comply with the treatment plan and take measures on their own like eating right, weight loss etcor are in non-compliance i.e. not taking the medications as prescribed then the medical advice will not acquire desired results. This can have fatal implications. It was found via a survey that most patients do not comply with the treatment plan laid down for them by their clinicians.[21] To generate better results, patients need to be engaged. There is growing emphasis on using machine learning and business rules engines to intervene and produce better patient care.[22] Messaging alerts and relevant, targeted content that can provoke patients to act in the manner they need to at vital moments which benefit their health, is a promising field in research.

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[20] Low LL, Lee KH, Ong MEH et al. Predicting 30-Day readmissions: performance of the LACE index compared with a regression model among general medicine patients in Singapore. Biomed Research International 2015;2015;169870.

[21] Davenport TH, Hongsermeier T, Mc Cord KA. Using AI to improve electronic health records. Harvard Business Review 2018. https://hbr.org/2018/12/using-ai-to-improve-electronic- health-records.

[22] Volpp K, Mohta S. Improved engagement leads to better outcomes, but better tools are needed. Insights Report. NEJM Catalyst, 2016, https://catalyst.nejm.org/patient-engagement- report-improved-engagement-leads-better-outcomes-better-tools-needed.

Another growing focus in healthcare is on the way choices are presented to patients to get them to choose and behave in a more anticipatory way (choice architecture). This is done based on real-world evidence. Through information provided by provider EHR systems, like watches, smartphones etc, software can cater to patients with appropriate recommendations to combat their ailments, by comparing the patient data to other effective treatment given to others with similar cases. The suggestions can be issued to different stakeholders in healthcare like patients or nurses and such.

Administrative Applications

There are also many administrative applications in healthcare, which are not as revolutionary as in patient care, but are very efficient in healthcare nevertheless. The average US nurse spends quarter of work time on regulatory and administrative activities.[23]AI technology can be used for a variety of administrative applications in healthcare, including claims processing, documentation, medical records management.[24]

Some healthcare organisations have also experimented with chatbots for patient interaction, health, and telehealth. These chat boxes may be useful for simple transactions like refilling prescriptions, but they require sharing of personal data which can cause concern to the patient regarding revealing such data. Patients have expressed privacy concerns about revealing such confidential information and how it was going to be used.[25]

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[23] Berg S. Nudge theory explored to boost medication adherence. Chicago: American Medical Association, 2018. www.ama-assn.org/ delivering-care/patient-support-advocacy/nudge-theory-explored- boost-medication-adherence.

[24] Commins J. Nurses say distractions cut bedside time by 25%. HealthLeaders, 2010. www.healthleadersmedia.com/nursing/ nurses-say-distractions-cut-bedside-time-25.

[25] UtermohlenK. Four robotic process automation (RPA) applications in the healthcare industry. Medium, 2018. https://medium.com/@ karl.utermohlen/4-robotic-process-automation-rpa-applications-in- the-healthcare-industry-4d449b24b613.

Machine learning is very useful for administration tasks like claims and payments. Insurers have to verify whether the bulk of claims are correct. Reliably identifying, analysing and correcting coding issues and incorrect claims saves all stakeholders in healthcare. Incorrect claims that slip through the cracks constitute significant financial damage waiting to be unlocked through data-matching and claims audits.

Implications for the Healthcare Workforce

There has been considerable discussion on the concern that AI will lead to loss of jobs and displacement of the workforce, due to workers being replaced by AI i.e. automation. It was suggested that a significant chunk of healthcare jobs could be automated within 10-20 years in the UK.[26] Other studies have suggested that while some automation of jobs is possible, a variety of external factors besides technology could limit job loss. These factors include the significant cost of AI technologies, labour market, benefits of automation beyond simple labour substitution, acceptance in regulations and society.[27] These factors might restrict actual job much lesser than what is speculated. Thus far there have been no known job eliminations by AI in health care. The difficulty of integrating AI into the healthcare system has been somewhat responsible for the lack of job impact. If automation is to happen, it would likely be for jobs involving digital information, radiology as opposed to jobs dealing with direct patient contact. [28] But even in such jobs

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[26] User Testing. Healthcare Chatbot apps are on the rise but the overall customer experience (cx) falls short according to a User Testing Report. San Francisco: User Testing, 2019.

[27] Deloitte.Frombrawntobrains:Theimpactoftechnologyonjobsin the UK. Deloitte, 2015. www2.deloitte.com/content/dam/Deloitte/ uk/Documents/Growth/deloitte-uk-insights-from-brawns-to-brain.pdf.

[28] McKinsey Global Institute. A future that works: automation, employment, and productivity. McKinsey Global Institute, 2017. www.mckinsey.com/~/media/mckinsey/featured%20insights/ Digital%20Disruption/Harnessing%20automation%20for%20 a%20future%20that%20works/MGI-A-future-that-works- Executive-summary.ashx.

like in radiology, the penetration of AI into these fields is likely to be slow.

While deep learning is finding its way within radiology, there are multiple reasons why radiology jobs are not in any immediate risk of automation.[29]

First, is the limitation of AI to perform radiology tasks. Thousands of detection tasks are necessary for radiology beyond just image recognition and deep learning can only perform certain specific tasks like recognising only certain kind of images. Radiologists also consult with other physicians on diagnosis, and treat diseases based on images which need to be generated by tailoring it to the particular patient's medical condition, relate findings from images to other medical records and test results, discuss procedures and results with patients, and many other activities.

Second, AI-based images are a long way from being ready for daily use in healthcare. Different imaging technology learning algorithms have different focus points which make it very difficult to embed deep learning systems into current clinical practice.

Third, deep learning algorithms for image recognition require labelling of data as there are millions of images from patients who have received a definitive diagnosis of cancer, a broken bone or other pathology and they need to be organised within labels. However, there is no such storage of radiology images and data, for deep learning to function with.

Finally, substantial changes will be required in medical regulation and health insurance for AI to be used in image analysis to take off. Because of these reasons, automation of healthcare is unlikely anytime soon. There is also the possibility that new jobs will be created to work with where AI technologies can be used. But same or more employment of people in

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[29] Davenport TH, Kirby J. Only humans need apply: Winners and losers in the age of smart machines. New York: HarperBusiness, 2016.

healthcare also means that medical costs would not substantially reduce anytime until it is possible to properly integrate AI into the healthcare sector.

Ethical Implications

Finally, the ethical issues surrounding AI needs to be addressed. The most obvious are privacy, transparency, accountability, and use of the confidential data being shared via AI. Transparency is perhaps the most difficult. Many AI algorithms particularly used for image analysis are virtually impossible to explain. Thus, while a patient may know if they have cancer, they will not be able to know why or what exactly is wrong as such algorithms can even stump physicians who are familiar with their functioning. With explanations being difficult to interpret, if mistakes are made by AI systems in patient diagnosis and treatment it may be difficult to establish accountability for them. There are also likely to be incidents in which patients receive medical information from AI systems which they would prefer to receive from a doctor who would be more empathetic to their condition being a human, thus jeopardizing patient interaction. Machine learning systems in healthcare may also be subject to algorithmic bias, and it might result in medical predictions based on gender or race when those are not actually causal factors.[30]

We are likely to come across many ethical, medical, occupational and technological changes with AI in healthcare. It is important that healthcare institutions, as well as governmental and regulatory bodies, establish structures and a proper policy to monitor key issues react in a responsible manner and establish governance mechanisms to limit negative implications.

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[30] Davenport TH, Dreyer K. AI will change radiology, but it won't replace radiologists. Harvard Business Review 2018. https://hbr.org/2018/03/ ai-will-change-radiology-but-it-wont-replace-radiologists.

The Future of AI in Healthcare

We believe that AI via machine learning has an important role to play in the healthcare in the future. In the form of machine learning, it is the primary capability behind the development of precision medicine, widely agreed to be a sorely needed advance in care. Although initial AI integration in providing diagnosis and treatment recommendations has had obstacles, it is expected that AI will ultimately master that domain as well. Given the rapid inroads AI is making in image analysis, AI will take over radiology and pathology images sometime are what are anticipated. Speech and text recognition are already employed for tasks like patient communication and capture of clinical notes, and their usage will increase.

The greatest barrier to AI in these areas is not if the technologies will be capable enough to be useful, but rather ensuring proper implementation in daily clinical practice. For large scale adoption to take place, AI systems must be properly standardized for use and physicians must be properly trained in handling these technologies. It will take a long time to overcome these barriers and thus AI in healthcare is an idea that is still sometime away from implementation.

It has also become apparent that AI systems will not replace medical personnel on a large scale, but rather will augment their efforts to care for patients. Over time, these personnel may move onto jobs which require human skill along like human qualities of empathy and persuasion. Perhaps the only healthcare providers who will lose their jobs over time may be those who refuse to work alongside artificial intelligence.[31]

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[31] Char DS, Shah NH, Magnus D. Implementing machine learning in health care – addressing ethical challenges. N Engl J Med 2018;378:981–3.