ORIGINAL RESEARCH PAPER

Volume - 9 | Issue - 7 | July - 2020 | PRINT ISSN No. 2277 - 8179 | DOI : 10.36106/ijsr

INTERNATIONAL JOURNAL OF SCIENTIFIC RESEARCH

MACHINE LEARNING IN RADIOLOGY: CURRENT PERSPECTIVE

Radiodiagnosis

Dr Mayur Pankhania* DMRD, DNB, EDiR, Sahyog Imaging centre, Department of Radiodiagnosis, PDU Medical College & Government Hospital, Rajkot, Gujarat, India *Corresponding Author

Dr Aditya Mehta Resident MD Radiology, Department of Radiodiagnosis, PDU Medical College & Government Hospital, Rajkot, Gujarat, India

Dr Krushnadas Radadiya MD Radiology, Rajkot, Gujarat, India

ABSTRACT

Recent most promising areas of health innovation is the application of artificial intelligence (AI) and Machine learning (ML) techniques in medical imaging. Historically, in radiology practice, trained physicians visually assessed medical images for the detection, characterization and monitoring of diseases. AI methods excel at automatically recognizing complex patterns in imaging data and providing quantitative, rather than qualitative, assessments of radiographic characteristics. The higher efficiency provided by AI and ML will allow radiologists to perform more value-added tasks, becoming more visible to patients and playing a vital role in multidisciplinary clinical teams. In this article, the authors review examples of current scope and applications of machine learning techniques in diagnostic radiology. In addition, the future impact and natural extension of these techniques in radiology practice are discussed.

KEYWORDS

Radiology, Machine Learning, Artificial Intelligence

INTRODUCTION

We live in a rapidly evolving world today. Science in general, information technology (IT) and computing power in particular has spurred the emergence of Artificial Intelligence (AI) and its applications in our day to day life.

With the introduction of IT, medical sciences have seen a paradigm change in the way diseases are identified, diagnosed and patients are treated. AI and its branches like machine learning (ML) and Deep learning (DL) are emerging as one of the most crucial part of health care provision. Of all the medical fields, radiological sciences are being influenced the most.

There are multiple schools of thoughts regarding the use of ML and DL in radiology. While few are optimistic, there is also fear that AI will replace healthcare providers one day. A recent survey of AI experts conducted by Grace et al. mentioned that, for some complex tasks, AI will outperform humans in many activities in the next decade. Experts believed that there is a likelihood of a 50% chance of AI surpassing human skills in 45 years(1)

While both the medical and IT are evolving every day and only time can demonstrate the true influence of AI, it is imperative that we understand the evolution and current scenario of ML and DL in radiology in order to keep up with the changing tide.Familiarity with the concepts, strengths, and limitations of computer-assisted techniques based on ML and DL is critical to ensure optimal patient care.

DEFINITION

Artificial intelligence (AI) is defined as computer systems able to perform tasks normally requiring human intelligence. e.g visual perception, speech recognition, decision making, and language translating.(2). Machine learning is the process by which a computer is able to improve its own performance (as in analysing image files) by continuously incorporating new data into an existing statistical model.(3) Deep learning (DL) , is a form of machine learning in which multiple layers of nodes exist between the input and output layers, simulating layers of neurons in a so-called artificial neural network.—(4) DL underpins many of the notable recent advances like speech recognition, image classification, text translation, and self-driving vehicles.

TYPES IN MACHINE LEARNING

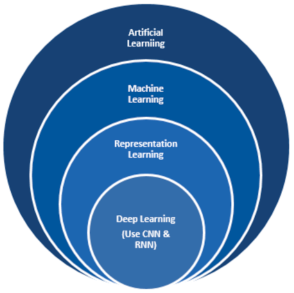
ML is generally categorized into 2 types, supervised and unsupervised.(5)

The first uses handcrafted engineered features that are defined in terms of mathematical equations (such as tumour texture) and can thus be quantified using computer programs.(6)

The second method, of which deep learning is a part can automatically learn feature representations from data without the need for prior definition by human experts.(7)

It is the evolution of second type what is presently called as the third era of IT, that has led to DL. Here the artificial neuronal networks that resemble the human neurons in complexity and function are created. These networks have nodes that are similar to the synapses in the human brain and would work in multiple layers. We still do not know of how some of these layers work and that is why these layers are called as hidden layers. These systems and neurons are self-improving and can work with unlabelled raw data and can draw their own inferences over the time without the need of human command.

Figure 2: Artificial Intelligence and Related Terms



Evolution Of Machine Learning And Deep Learning

The application of logic and statistical pattern recognition to problems in medicine has been proposed since the early 1960s(8)(9).The earlier application of AI lead to the emergence of computer-aided detection (CAD) during the 1980s and 1990s.(10) CAD was used widely in clinical imaging. Some of the early applications of CAD were in screening mammography and CXR.CAD turned out to be a disappointment for radiologists. (10) Several large trials came to the conclusion that CAD has at best delivered no benefit and at worst has actually reduced radiologist accuracy, resulting in higher recall and biopsy rates. (10)

Current Status And Literature

AI and the way it works have seen tremendous changes in the recent times. Some of those tasks were not feasible previously; recent advances in machine learning have made them possible. Since 2010 substantial success has been made in deep learning, producing systems able to learn without having to be explicitly programmed by building a model from sample inputs. Severalmodels related to medical and cardiovascular fields have already been published.(5)

Chilamkurthy et al used a large dataset to produce a system that can detect a variety of critical findings on CT head scans.(11) Rajpurkar et al. demonstrated how their CNN, called the CheXNext algorithm, had roughly the same detection results, with high AUC and CIs, as radiologist recognition and classification of chest pathologies. (12)In 2017, successful use of deep neural networks was reported for the analysis of skin cancer images with greater accuracy than a dermatologist and the diagnosis of diabetic retinopathy from retinal images.(4)In one example, published in an article about cardiovascular disease prediction in the Journal of the American Heart Association (JAHA), a machine learning risk calculator outperformed the American College of Cardiology/American heart Association (ACC/AHA) risk calculator by recommending less drug therapy and missing fewer cardiovascular disease events. The findings demonstrated the potential of machine learning for improving cardiovascular risk prediction and assisting in medical decision-making(13).

While some of the models have successfully demonstrated the immense potential of ML, there are other examples where ML have failed to reach the expectations. The fear and apprehension around AI and it's implications on the future of radiology are not unfound. Without doubt, there will be job shortages, particularly in private health services, at all levels, from receptionists to healthcare assistants to higher level managers and, finally, radiologists. Every disruptive technological innovation was received with caution. AI is nothing new. Nonetheless, like other disruptive technologies, the potential benefits of AI in healthcare should not be underestimated.

The primary driver behind the emergence of AI in medical imaging has been the desire for greater efficacy and efficiency in clinical care. A seamlessly integrated AI component within the imaging workflow would increase efficiency, reduce errors and achieve objectives with minimal manual input by providing trained radiologists with pre-screened images and identified features.

ML technologies may not always work as a replacement but would also act to supplement and compliment the work of radiologists. While it is true in theory that one day this hyper intelligence can dominate the humans and may over power them, it is determined by many other factors. The U.S. Department of Health and Human Services (HHS), with support from the Robert Wood Johnson Foundation, asked JASON to consider how AI will shape the future of public health, community health, and health care delivery. JASON is an independent group of elite scientists which advises the United States government on matters of science and technology, mostly of a sensitive nature. The report submitted by them states that the design of future health care information systems revolves around two questions that need to be answered, one concerned with computer science and the other with fundamental biology. (13)

"The computer science question is, whether an entire medical database can be created and used with the data maintained in a form accessible to human cognition, avoiding the cumbersome and costly translation from analog to digital. The fundamental biology question is whether the natural coding of information in a human brain is basically analog and not digital.**"**(13)

CHALLENGES

There are many technical challenges to be overcome before the boons of ML and DL can be reaped in medical field. Following are few of the technical challenges that we face today.

1. These models are data hungry and require huge sets of labelled data to be trained and tested. Large amounts of big health data are still recorded as text and are mostly collected for purposes other than research making it difficult to obtain. Privacy concerns for clinical images, as well as the costs and difficulties of obtaining accurate ground-truth labels from multiple experts or pathology diagnoses is a huge challenge in creating the models. IBM Watson's project with the MD Anderson Cancer Centre was halted after 4 years of development and Google DeepMind's partnership with Royal Free London NHS Foundation trust came under fire for inappropriate sharing of confidential patient data. (8)
2. Though some of these models may work in experimental setting, Translating technical success to meaningful clinical impact is a great challenge. (5)
3. It is still unclear how AI works and how it arrives at its outcomes; these areas will likely remain, at least for a time, this gives doubts about the reliability and generalisability of AI methods.
4. Deep learning systems currently excel in emulating the kind of human judgment that is based purely on pattern recognition and most models are task-specific and must be further developed to handle more complex diagnostic studies (14)

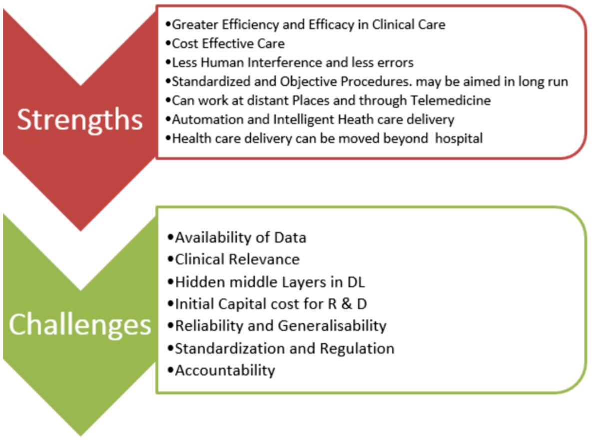


Figure 1: Strengths and Challenges

Apart from the technical challenges there are economic, ethical and regulatory aspects that should be considered when talking about the ML and DL in radiology.

Indian Scenario & Regulation

India has one of the least doctor patient ratios among its peers. According to one of the reports, the estimated doctor patient ratio (Allopathy) in India in 2017 was 0.6: 1000 when the WHO recommendation is a minimum of 1:1000.(15) When people are deprived of primary health care, it is a far away dream to have a radiologist when they need one. There are also urban rural divides with most of the imaging facilities available in the urban areas. ML can have an huge impact in tele medicine and would help in reaching the unreached.

The future of AI would also depend on the investment that is flowing into the research and development. There has been a large amount of investment in AI in recent times. for example Healthcare organizations surveyed by Optum said they planned to invest an average of $32.4 million over the next five years on artificial intelligence.(13) These may be giving potential cues towards the future of ML in medical imaging. ML has the potential to improve different steps of the radiology workflow including order scheduling and triage, clinical decision support systems, detection and interpretation of findings, post-processing and dose estimation, examination quality control, and radiology reporting.

Another important aspect to be considered is how these new innovations are regulated. Every medical device that has to be used mainstream has to go through a stringent testing before it is approved for use. The potential advantages and disadvantage are weighed before a medical device is approved. There is an increase in the number of FDA approvals of devices using AI in 2018.(13)The EU is introducing new regulations that will apply as of May 26, 2020, regulations that contain additional provisions that specifically address software medical devices. Of particular relevance, software with a medical purpose of "prediction and prognosis" will fall within the scope of the Regulations.(13) The hidden layers and mystery of inner workings of DL is one of the main concerns to be answered when approving the devices based on AI.

Another question that needs to answer before the approval of technologies based on AI is the onus of guilt in times of adverse events. If there is an adverse events or mistakes in patient care, who will be held responsible? Will it be the radiologist or the Model or the person who engineered the device?

CONCLUSION

To conclude, AI and ML are here to stay and evolve. ML encompasses many powerful tools with the potential to dramatically increase the information radiologists extract from images and it will changes radiology dramatically as the advent of cross-sectional imaging did. Partnerships between radiologist, clinicians and data scientists, supported by growing strength of clinical informatics, are beginning to give hopes for the near future when ML can be completely integrated into the medical imaging. However, AI requires a thorough and systematic evaluation before its integration into routine clinical care. But the success of machine learning in so many "human" domains is unprecedented and a degree of optimism is justified.

REFERENCES:

1. Grace K, Salvatier J, Dafoe A, Zhang B, Evans O. When Will AI Exceed Human Performance? Evidence from AI Experts. 2017 May 24 [cited 2019 Aug 23]; Available from: http://arxiv.org/abs/1705.08807
2. Oxford Living Dictionaries. Artificial intelligence description in English.
3. Webster Merriam. Machine Learning | Definition of Machine Learning by Merriam-Webster [Internet]. Merrium Webster. [cited 2019 Aug 24]. Available from: https://www.merriam-webster.com/dictionary/machine learning
4. The Lancet. Artificial intelligence in health care: within touching distance. Vol. 390, The Lancet. Lancet Publishing Group; 2017. p. 2739.
5. Parthiban L SR. Intelligent heart disease prediction system using CANFIS and genetic algorithm. [cited 2019 Aug 23]; Available from: http:// citeseerx. ist.psu. edu/viewdoc/download?doi=10.1.1.451.9421&rep=rep1&type=pdf
6. Castellino RA. Computer aided detection (CAD): An overview. Vol. 5, Cancer Imaging. 2005. p. 17–9.
7. Shen D, Wu G, Suk H-I. Deep Learning in Medical Image Analysis. Annu Rev Biomed Eng [Internet]. 2017 [cited 2019 Aug 23];19:221–48. Available from: http://www.ncbi.nlm.nih.gov/pubmed/28301734
8. Ledley rs, lusted lb. Reasoning foundations of medical diagnosis; symbolic logic, probability, and value theory aid our understanding of how physicians reason. Science [Internet]. 1959 Jul 3 [cited 2019 Aug 23];130(3366):9–21. Available from: http://www.ncbi.nlm.nih.gov/pubmed/13668531
9. Lodwick gs, keats te, dorst jp. The coding of roentgen images for computer analysis as applied to lung cancer. Radiology [Internet]. 1963 Aug [cited 2019 Aug 23];81:185–200. Available from: http://www.ncbi.nlm.nih.gov/pubmed/14053755
10. Oakden-Rayner L. The Rebirth of CAD: How Is Modern AI Different from the CAD We Know? Radiol Artif Intell [Internet]. 2019 May 29 [cited 2019 Aug 24];1(3):e180089. Available from: http://pubs.rsna.org/doi/10.1148/ryai.2019180089
11. Chilamkurthy S, Ghosh R, Tanamala S, Biviji M, Campeau NG, Venugopal VK, et al. Deep learning algorithms for detection of critical findings in head CT scans: a retrospective study. Lancet [Internet]. 2018 Dec 1 [cited 2019 Aug 25]; 392(10162):2388–96. Available from: http://www. ncbi. nlm. nih. gov/ pubmed/ 30318264
12. Rajpurkar P, Irvin J, Ball RL, Zhu K, Yang B, Mehta H, et al. Deep learning for chest radiograph diagnosis: A retrospective comparison of the CheXNeXt algorithm to practicing radiologists. PLoS Med. 2018 Nov 1;15(11).
13. AI & the FDA - By Amrit Virdee [Internet]. [cited 2019 Aug 23]. Available from: https://hackernoon.com/demystifying-the-current-upward-trend-in-fda-approvals-of-medical-devices-using-artificial-cb9cc18d175
14. Yasaka K, Akai H, Kunimatsu A, Kiryu S, Abe O. Deep learning with convolutional neural network in radiology. Jpn J Radiol [Internet]. 2018 Apr [cited 2019 Aug 23];36(4):257–72. Available from: http://www.ncbi.nlm.nih.gov/pubmed/29498017
15. India: Less than one doctor for 1000 population in India: Government to Lok Sabha - The Economic Times [Internet]. [cited 2019 Aug 25]. Available from: https://economictimes.indiatimes.com/industry/healthcare/biotech/healthcare/less-than-one-doctor-for-1000-population-in-india-government-to-lok-sabha/articleshow/59697608.cms?from=mdr#targetText=It gives a doctor-population,population ratio of
16. Farmer JD, Lafond F. How predictable is technological progress? Res Policy. 2016 Apr 1;45(3):647–65.