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Will artificial intelligence support or replace neuroradiologists 10 years from now?

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Artificial Intelligence (AI) applications are being integrated into everyday medical practice at an accelerated rate[1].Radiologists in particular have exponentially increased their interest in the applications of AI in medical imaging. This is evidenced by the proliferation of peer-reviewed publications in AI from almost 200 in 2010 to close to 1000 in 2019[2]. It is expected that AI will continue being integrated into everyday medical practice and will transform medical care in the future. Radiologists have met this development with equal excitement and apprehension. Whilst AI has so far produced promising results in the field of medical imaging[3], its continued implementation creates a threat to the job security of neuroradiologists. This essay will discuss the various applications of artificial intelligence in neuroradiology and explain why AI will support rather than replace the neuroradiologist in the next decade.

What is artificial intelligence?

AI simply refers to the "ability of digital computers to perform tasks which are commonly associated with human intelligence[4]." There are different subsets of artificial intelligence but for the purposes of this essay we will focus on Machine Learning (ML) as it is the most relevant to medical imaging. ML tools work by analysing multiple example inputs and drawing out patterns in order to solve a task[2,3,5,]. By creating unified algorithms from diverse data sets and combining them with other healthcare metrics, machine learning tools can help predict outcomes[2]. The most important form of ML in neuroradiology is deep learning (DL) where the computers usually have layers of algorithms which can be sorted into more meaningful data or less meaningful data[2]. This means that DL models can be trained to perform precise image recognition tasks and may even be useful in discovering novel disease characteristics[2,6].

Why does the neuroradiologist need AI?

Neuroradiologists now face larger volumes of images to produce and interpret in the midst of a looming doctor's shortage[7,8]. Additionally, with the increasing complexity of neuroradiology, there is a corresponding increased need for more detailed sub specialist reports[8]. Neuroradiologists therefore require more tools in their arsenal will which allow them to accurately process and interpret a larger number of images over a shorter period of time. AI now allows automation of the image processing procedure which, together with the augmented computing capacity, higher data transfer speeds and affordable data storage can greatly facilitate the work of neuroradiologists[9,10].

How will AI support the neuroradiologist?

Artificial intelligence provides neuroradiologists with tools that can not only identify, characterise and classify abnormalities but also provide solutions for problems faced in the routine diagnosis tasks[8,9,10,11]. These applications are exciting because they will save time, ameliorate accuracy, increase efficacy, fill gaps in the field of neuroimaging and create new links between biology and disease[12]. Even so, there is still potential for further integration of AI into everyday clinical practice. AI will support the neuroradiologist in the following ways:

Eliminating mundane tasks

In everyday practice, neuroradiologists do a significant amount of drudge work especially in the

initial and later stages of the workflow including scheduling, acquisition, pre-processing, reporting and communication [9,12]. Interpreting images also involves repetitive tasks such as quantifying distances[1] or delineating stroke lesions[13]. At the moment, there are a limited number of AI applications/functions which address this need. The automation of these repetitive rote tasks would allow neuroradiologists to process a higher number of images more accurately over a shorter period of time[2,3]It may even mean that radiologists have more time to interact one-on-one with the patients[12].

Triage and workplace prioritisation

When a request is made for the imaging to a suspected emergent acute neurological event, a trained neuroradiologist must perform the arduous task of triaging it based of their health centre's protocols[11]. Computer-aided triage devices can ease work-list prioritisation for neurological events such as traumatic brain injury (TBI), aneurysm, large vessel occlusion (LVO) and acute infarction [2]. Deep learning tools so far have successfully been used to prioritise image review based in acuity[11]. By removing the otherwise time-consuming task of triaging, artificial intelligence applications/functions will increase the number of positive outcomes and preserve neurological function in patients who have experienced an acute neurological event.

Detection

Given the critical nature of many neurological events, rapid detection is essential for optimal outcome.Deep learning tools have, so far, proven useful for the detection of large vessel occlusion (LVO) in ischemic stroke[14]. Moreover, several AI modules have been developed which can either predict a diagnosis of Alzheimer's Disease (AD) later in life, predict progression of mild neurodegenerative disease to AD or differentiate between the different types of dementia[11]. In the field of neuro-oncology, AI in combination with clinical, radiomics and molecular markers has shown some success in identifying brain tumors and differentiating them form non-neoplastic lesions[10]. Furthermore, with the use of AI tools, brain tumors can be graded and assessed pre- and post treatment[10]. In patients with MS, AI can be used to identify and quantify white matter lesions; a task which are otherwise time-consuming tasks with low reproducibility[3]. More rapid detection of these and other such neurological events translates to expedited diagnosis, earlier opportunities to administer life-saving treatment and improved prognosis[3,10,11,14].

Standardisation

The interpretation of medical images is prone to intra and inter observer variability as well as inter-scanner variability[3]. Because AI applications/functions can be trained to perform tasks in the exact same way, they can facilitate the production of high quality reproducible images while still accommodating different scanning requirements[3]. This harmonization of data, would enable neuroradiologists to carry out longitudinal and multicentre studies with greater ease.

Which functions of AI can potentially replace the neuroradiologist?

There is palpable fear amongst neuroradiologists that they will be completely replaced by AI in the next decade. The processing and analytical power of computers far exceeds that of humans. AI tools can not only notice subtle details which humans cannot but can also create new ways of interpreting medical images beyond human understanding[12]. Furthermore, there is potential that with continued development, AI will replace certain tasks of the neuroradiologist all together[9,11].

Few tools exist which replace tasks all together. However, there are exceptions. The application VIZ LVO, in the event of an LVO, automatically notified the stroke team on call[9]. Additionally, the AI reader app (Qmenta) can facilitate diagnosis, give quantitative information and then automatically draft a report for the referring physician[9]. In other fields of medical imaging, AI tools which can independently make diagnosis without the input of a medical professional have already been approved[12].In the future, more apps will be developed that can completely take over certain tasks and further automate the neuroradiologist's workflow.

If AI continues to successfully replace particular tasks in the image interpretation process, it could be a useful tool in widening access to subspecialty expertise in deprived populations or countries[11,15]. Non-neuroradiologists could perhaps, through gadgets like mobile phones and computers seek expert opinions through AI tools. Such models have already been created by companies such as RAD-AID

in over 30 countries[16]and there is endless potential to do this in the field of neuroradiology as well.

Will AI support or replace the neuroradiologist?

The implementation of AI tools into everyday neuroradiological practice will benefit both neuroradiologists and patients. The neuroradiologist would no longer have to perform monotonous rote tasks and will therefore be freer to perform more productive tasks[2]. Patients will receive expedited diagnoses and there prompt delivery of treatment and better prognosis due to the reduced triaging and detection time[11,14].

The majority of AI applications are developed to facilitate faster and more accurate detection and interpretation of abnormalities in medical images[9]. To fully detect all possible findings on a medical image, numerous specific detection applications/ functionalities are needed[6]. Comparisons are usually drawn between AI tools and neuroradiologists based on their ability to detect a single disease or small set of diseases[15]. For AI tools rely on large data sets in order to work effectively and can therefore successfully identify common neurological conditions. On the other hand, the human radiologist is trained to identify both common conditions and those that are extremely rare[15] meaning that human input will almost always be required in addition to AI functions.

There are few applications which have the potential to replace the neuroradiologist but they can only do this for a restricted number of tasks for example pre drafting reports or automatically notifying stroke teams of an LVO[9]. Whereas artificial intelligence tools can be trained to perform a single specific task extremely well, neuroradiologists can perform several tasks/ a sequence of tasks well. This means that even if some AI applications/functions will completely replace certain tasks that the neuroradiologist does, the neuroradiologist will still have other tasks which they can focus on as their scope of work goes beyond reading images and drafting reports[6].

Even if AI is unlikely to replace neuroradiologists in the next decade, it will significantly impact everyday practice. Radiologists must adapt to using AI to facilitate their everyday work; those who do not may become obsolete in the next decade.

References

1. Sapanel Y. WILL AI REPLACE RADIOLOGISTS ANYTIME SOON? [Internet]. Linkedin.com. 2020 [cited 17 June 2022]. Available from: https://www.linkedin.com/pulse/ai-replace-radiologists-anytime-soon-yoann-sapanel-1d

2. Lui Y, Chang P, Zaharchuk G, Barboriak D, Flanders A, Wintermark M et al. Artificial Intelligence in Neuroradiology: Current Status and Future Directions. AJNR American Journal of Neuroradiology [Internet]. 2020 [cited 22 June 2022];41(8):E52-E59. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7658873/

3. Cacciaguerra L, Storelli L, Rocca M, Filippi M. Current and future applications of artificial intelligence in multiple sclerosis. Augmenting Neurological Disorder Prediction and Rehabilitation Using Artificial Intelligence [Internet]. 2022 [cited 22 June 2022];:107-144. Available from: https://www.sciencedirect.com/science/article/pii/B9780323900379000126

4. Muthukrishnan N, Maleki F, Ovens K, Reinhold C, Forghani B, Forghani R. Brief History of Artificial Intelligence. Neuroimaging Clinics of North America [Internet]. 2020 [cited 23 June 2022];30(4):393-399. Available from: https://www.sciencedirect.com/science/article/abs/pii/S105251492030054X?via%3Dihub

5. Kaka H, Zhang E, Khan N. 'Artificial Intelligence and Deep Learning in Neuroradiology: Exploring the New Frontier. Canadian Association of Radiologists Journal [Internet]. 2020 [cited 22 June 2022];72(1):35-44. Available from: https://journals.sagepub.com/doi/10.1177/0846537120954293

6. Davenport T, Dreyer K. AI Will Change Radiology, but It Won't Replace Radiologists [Internet]. Harvard Business Review. 2018 [cited 22 June 2022]. Available from: https://hbr.org/2018/03/ai-will-change-radiology-but-it-wont-replace-radiologists

7. Hainc N, Federau C, Stieltjes B, Blatow M, Bink A, Stippich C. The Bright, Artificial Intelligence-Augmented Future of Neuroimaging Reading. Frontiers in Neurology [Internet]. 2017 [cited 23 June 2022];8. Available from: https://www.frontiersin.org/articles/10.3389/fneur.2017.00489/full

8. Haller S, Van Cauter S, Federau C, Hedderich D, Edjlali M. The R-AI-DIOLOGY checklist: a practical checklist for evaluation of artificial intelligence tools in clinical neuroradiology. Neuroradiology [Internet]. 2022 [cited 22 June 2022];64(5):851-864. Available from: https://link-springer-com.ezproxy.st-andrews.ac.uk/article/10.1007/s00234-021-02890-w#citeas

9. Olthof A, van Ooijen P, Rezazade Mehrizi M. Promises of artificial intelligence in neuroradiology: a systematic technographic review. Neuroradiology [Internet]. 2020 [cited 23 June 2022];62(10):1265-1278. Available from: https://pubmed.ncbi.nlm.nih.gov/32318774/

10. Abdel Razek A, Alksas A, Shehata M, AbdelKhalek A, Abdel Baky K, El-Baz A et al. Clinical applications of artificial intelligence and radiomics in neuro-oncology imaging. Insights into Imaging [Internet]. 2021 [cited 23 June 2022];62(10):1265-1278. Available from: https://link.springer.com/article/10.1007/s00234-020-02424-w

11. Fiani B, Pasko K, Sarhadi K, Covarrubias C. Current uses, emerging applications, and clinical integration of artificial intelligence in neuroradiology. Reviews in the Neurosciences [Internet]. 2021 [cited 22 June 2022];33(4):383-395. Available from: https://www.degruyter.com/document/doi/10.1515/revneuro-2021-0101/html

12. Reardon S. Rise of Robot Radiologists. Nature [Internet]. 2019 [cited 23 June 2022];576(7787):S54-S58. Available from: https://www.nature.com/articles/d41586-019-03847-z

13. Gillebert C, Humphreys G, Mantini D. Automated delineation of stroke lesions using brain CT images. NeuroImage: Clinical [Internet]. 2014 [cited 23 June 2022];4:540-548. Available from: https://pubmed.ncbi.nlm.nih.gov/24818079/

14. Murray N, Unberath M, Hager G, Hui F. Artificial intelligence to diagnose ischemic stroke and identify large vessel occlusions: a systematic review. Journal of NeuroInterventional Surgery [Internet]. 2019 [cited 22 June 2022];12(2):156-164. Available from: https://pubmed.ncbi.nlm.nih.gov/31594798/

15. Langlotz C. Will Artificial Intelligence Replace Radiologists?. Radiology: Artificial Intelligence [Internet]. 2019 [cited 22 June 2022];1(3):e190058. Available from: https://pubs.rsna.org/doi/full/10.1148/ryai.2019190058

16. Mollura D, Culp M, Pollack E, Battino G, Scheel J, Mango V et al. Artificial Intelligence in Low- and Middle-Income Countries: Innovating Global Health Radiology. Radiology [Internet]. 2020 [cited 22 June 2022];297(3):513-520. Available from: https://pubs.rsna.org/doi/10.1148/radiol.2020201434?url_ver=Z39.88-2003&rfr_id=ori:rid:crossref.org&rfr_dat=cr_pub%20%200pubmed