British Society of Neuroradiologists
Prof Iain Wilkinson Undergraduate Essay Prize 2022 Winner

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

Syed Muzaffar Abbas, Fifth Year Medical Student, University of Southampton

Introduction

Artificial intelligence (AI) is a polarising topic that sparks both excitement, and apprehension in today's world. From the term first coined in 1956 by Minsky and McCarthy, six years after the invention of the infamous works of Alan Turing on the Turing Test and the Bombe, AI has grown rapidly to where it is being implemented widely in many sectors.

The National Health Service (NHS) is also seeking to widely involve such technologies. In 2019, the Chief Executive of the NHS, stated that the NHS would kickstart a global call for evidence to "incentivise the use of safe and evidence-based AI and machine learning technologies across the NHS" with the long-term goal of helping the NHS to become a world leader in the use of AI.[1]

Radiology is a speciality which already heavily utilises computing and machine technologies in diagnostic imaging. Hence, it follows that as more advanced intelligent technologies develop, their use will be inevitable and most pertinent to radiology. According to estimates by the Royal College of Radiology (RCR), neuroradiology is overall the third most popular (12%) amongst all sub-specialising interests amongst trainees.[2]

The 2021 RCR workforce census concluded that despite an increasing number of specialist trainees and a 5% increase in consultants per year since 2016, the radiology workforce shortage is estimated to be 29%, and this is forecasted to grow to a 39% shortage by 2026.[3]

As AI's capabilities progress, it could serve as a tool to aid neuroradiologists reporting, in both accuracy and efficacy. Furthermore, using AI could be one of many strategies to combat the shortage of radiologists. However, as AI advances over the next 10 years, many neuroradiologists may fear that AI will progress beyond the role of assistance to wholly replace them and thus rendering their role obsolete.

Current Landscape

Neuroradiology primarily deals with identifying abnormalities of the central and peripheral nervous system, spine, head and neck and spinal cord. CT and MRI are the two most performed scans within neuroradiology.[4] Data collected as part of the 2021 NHS Diagnostic Imaging Dataset (DID) showed that excluding 2020-2021, the number of CT and MRI scans performed has increased year on year since 2012/13. A fall in 2020-2021 was attributed to the COVID-19 pandemic.[5] With greater workforce shortages, and an increasing number of neuroradiological scans being performed, a concern may be that the raw number of scan errors will also increase. The DID additionally showed a gradual increase in the median test to report time for MRI (brain) from 2 days in 2012-2014, to 3 days in the period from 2014-2020.[5]

As demonstrated by Lui et al.[6] research on AI and its relevance to neuroradiology has rapidly grown over the past 10 years, with the total number of publications relating artificial intelligence (and synonymous terms) with the brain, increasing from approximately 200 in 2010 to almost 1000 in 2019 (p. 2). The NHS has developed its AI Lab Roadmap, providing £90 million in funding to develop safe, effective, and ethical forms of AI, and is soon to publish a national AI strategy for health and social care.[7]

Several companies provide AI platforms that are already available to the NHS. In the latest round of funding, 14 companies working on AI technologies, were awarded for procurement of AI platforms and software.[8] Many of these applications have uses within neuroradiology and are most of use in stroke (fig 1). Importantly the majority are also PACS integrable which is the recommended

Table 1 - of AI applications of use in Neuroradiology currently available to NHS England[9,11]

AI Application	Scan type compatibility	PACS integrable (Y/N)	Examples of use cases for investigation of pathology
Icobrain	CTP, MRI	Y	MS, dementia, epilepsy, TBI, stroke
Aidoc	Non-contrast CT, CTA	Y	Stroke
RapidAI	Non-contrast CT, CTA, CTP, MRI	Y	Stroke
e-stroke	Non-contrast CT, CTA, CTP	Y	Stroke
Viz	Non-contrast CT, CTA, CTP	N	Stroke
CinaHead	Non-contrast CT, CTA	Y	Stroke

standard for seamless use, by the RCR.[9] As of date, no national diagnostic imaging guidelines have been published by NICE on the use of AI for pathologies and investigations relevant to neuroradiology. NICE guidelines are in development on the use of AI in clinical decision-making for stroke, which are due to soon be published at the end of July 2022.[10] However, as part of this developing guideline, scoping documents and MedTech briefings reveal that the resource drain of AI technologies would be greater compared to existing CT and MRI scans.[11,12]

The long-term cost implication however is unclear, as the use of AI may result in more efficient reporting of CT and MRI scans by neuroradiologists. Additionally, AI may be able to prioritise cases of time-critical importance. Therefore, any cost savings in the long term due to the use of AI cannot be accurately quantified yet.

Olthof et al.[13] explored all AI applications worldwide currently of use in neuroradiology and identified 37 AI applications from 27 different companies in Asia, North America, and Europe. Most importantly the review found the majority (54%) of these applications to provide an "assistive" role to neuroradiologists rather than replacing their role (p. 5). One category of "assistive" roles identified included quantitative information such as the volume of haemorrhagic stroke. Another function was to automatically identify and highlight areas of interest such as large vessel occlusions on CT angiogram.[13]

However, it is important to recognise that AI applications can wholly replace some aspects of a neuroradiologist's workflow. Examples of this include the AI program ATROSCAN, which can quantify cortical thickness, and conduct a comparative analysis with age-identical reference data, to automate a report in cases of suspected dementia.[14]

Pearls and Pitfalls

The benefits and flaws of using AI systems should be considered, to assess whether they truly can replace the role of a neuroradiologist, or whether they will serve as a tool of assistance.

Human errors in reporting are bound to occur and this has been well evidenced within the relevant literature.[15] Eye strain and mental and physical fatigue are all inevitable factors, especially with the increasing demands of the speciality due to a shortage of radiologists. AI could serve a role to reduce these errors, as an algorithm is not prone to these human factors. However, this assumes a sufficient size dataset to adequately "train" the AI's algorithm.

AI could serve to streamline neuroradiologists' workflow at almost every stage. It could analyse past scans, extract pertinent patient details autonomously, and exclude pre-existing findings not relevant to the investigation. During scanning, AI could aid in standardising every scan, by detecting incorrect positioning, controlling for head motion, and reducing any artefacts. Post-scanning, AI could identify abnormalities and pre-sort a neuroradiologist's list, accounting for the abnormalities which are most time urgent, and showing them first to the clinician.

Another potential future advantage of AI is via the concept of machine learning; the ability to self-validate and learn from mistakes. Internal validation is whereby the system recognises its error and self-corrects its own data set, which the AI system's algorithm is based upon. External validation would allow the neuroradiologist to manually fine-tune the AI system that it has made an error and allow the AI system to update its algorithm to avoid errors.

Whilst these capabilities are very promising, AI systems are not without limitations. For an AI system's algorithm to accurately work, they require large datasets, and accurate labelling. Collating a large dataset may not always be possible for every pathology, and labelling is a cumbersome process. Furthermore, different pathologies may cause near similar or identical radiographic findings. An explored example of this is AI automating the segmentation of white matter lesions (WML), based on data from patients with multiple sclerosis. WML also can occur in cases of SLE, and it cannot be assumed that AI systems would be able to differentiate without the system being trained for this.[16]

Another major concern is that for AI to function, large amounts of patient data would need to be shared with many companies. This may result in a barrier to patient acceptance of engaging with such AI technologies, due to fear of their data being used for alternative reasons. Such fear would not be unjustified as data is highly valuable to companies for further developments, in the desire to find innovative solutions before their marketplace competition.

Conclusion

Langlotz[17] writes "' Will AI replace radiologists?' is the wrong question. The right answer is: Radiologists who use AI will replace radiologists who don't" (p. 2).

The use of AI technologies in neuroradiology is an exciting concept. Existing AI solutions being worked on undoubtedly have their benefits; mostly in assisting neuroradiologists' workflows. Nevertheless, it cannot be denied that AI currently does have the potential to replace a small number of neuroradiologists' roles. Future AI developments cannot completely be predicted and as AI technology develops, and as a result the view that AI could replace neuroradiologists is understandable. However, considering the current limitations that AI has, and the lack of long-term trials, wholly autonomous AI neuroradiology does not appear to be likely over the next 10 years. An AI-neuroradiologist collaborative model appears to be of greater likelihood, and one which has the potential to hugely improve outcomes for patients. In the next 10 years, the function of AI neuroradiology looks to be assistive rather than autonomous.

References

1. NHS England. NHS aims to be a world leader in artificial intelligence and machine learning within 5 years. 2019. Available from: https://www.england.nhs.uk/2019/06/nhs-aims-to-be-a-world-leader-in-ai-and-machine-learning-within-5-years [Accessed 19th March 2022].
2. Bhuva S, Parvizi N. Factors affecting radiology subspecialty choice among radiology registrars in the UK: a national survey. Clinical Radiology. 2016;71:S5.
3. RCR Clinical radiology census report 2021, The Royal College of Radiologists, 2021.
4. Stanford Medicine. Neuroimaging and Neurointervention (Neuroradiology) Available from: https://med.stanford.edu/neuroimaging/patients.html. [Accessed 19th March 2022].
5. NHS England. Diagnostic Imaging Dataset 2020-21 Data. 2021.
6. Lui YW, Chang PD, Zaharchuk G, Barboriak DP, Flanders AE, Wintermark M, et al. Artificial Intelligence in Neuroradiology: Current Status and Future Directions. AJNR Am J Neuroradiol. 2020;41(8):E52-e9. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC7658873/ [Accessed 25th March 2022].
7. NHS. NHS AI Lab roadmap. Available from: https://www.nhsx.nhs.uk/ai-lab/nhs-ai-lab-roadmap/ [Accessed 25th March 2022].
8. NHS Shared Business Services. The Provision of Artificial Intelligence (A.I), Imaging and Radiotherapy Equipment, Associated Products and Diagnostic Imaging. 2021.
9. The Royal College of Radiologists. Integrating artificial intelligence with the radiology reporting workflows (RIS and PACS). Available from: https://www.rcr.ac.uk/publication/integrating-artificial-intelligence-radiology-reporting-workflows-ris-and-pacs [Accessed 30th March 2022]
10. National Institute for Health and Care Excellence (NICE), Artificial intelligence (AI) software to help clinical decision making in stroke
: (NICE Guideline in development) [GID-DG10044] 2022. Available from: https://www.nice.org.uk/guidance/indevelopment/gid-dg10044 [Accessed 3rd March 2022].
11. NICE. Software with artificial intelligence derived algorithms for analysing CT brain scans in people with a suspected acute stroke. Available from: https://www.nice.org.uk/guidance/gid-dg10044/documents/final-scope [Accessed 3rd March 2022].
12. NICE. RapidAI for analysing CT/MRI brain scans in people with suspected acute stroke. Available from: https://www.nice.org.uk/advice/mib262/chapter/The-technology [Accessed 3rd March 2022].
13. Olthof AW, van Ooijen PMA, Rezazade Mehrizi MH. Promises of artificial intelligence in neuroradiology: a systematic technographic review. Neuroradiology. 2020;62(10):1265-78. Available from: https://pubmed.ncbi.nlm.nih.gov/32318774/ [Accessed 6th March 2022].
14. JLKGROUP. ATROSCAN AI based Brain Aging & Dementia Progress Analysis. Available from: https://jlkgroup.com/pdf/en/ATROSCAN_eng.pdf [Accessed 6th March 2022].
15. Kim YW, Mansfield LT. Fool me twice: delayed diagnoses in radiology with emphasis on perpetuated errors. AJR Am J Roentgenol. 2014;202(3):465-70. Available from: https://pubmed.ncbi.nlm.nih.gov/24555582/ [Accessed 12th March 2022].
16. Haller S, Van Cauter S, Federau C, Hedderich DM, Edjlali M. The R-AI-DIOLOGY checklist: a practical checklist for evaluation of artificial intelligence tools in clinical neuroradiology. Neuroradiology. 2022;64(5):851-64. Available from:

https://pubmed.ncbi.nlm.nih.gov/35098343/ [Accessed 19th March 2022].
17. Langlotz CP. Will Artificial Intelligence Replace Radiologists? Radiol Artif Intell. 2019;1(3): e190058. Available from: https://www.ncbi.nlm.nih.gov/pmc/articles/PMC8017417/ [Accessed 4th April 2022].