Artificial intelligence in neuro-radiology: overview of the current commercial landscape

RAD Magazine, 47, 548, 23

Dr Shah Islam

Neuroradiology clinical research fellow, Imperial College London; interventional and diagnostic neuroradiology fellow, National Hospital for Neurology and Neurosurgery, London

Introduction

The last decade has seen significant strides in the application of AI within the field of radiology. With the volume of imaging increasing at a rate far greater than recruitment of consultant radiologists, AI is often considered the panacea to a labour force in dire crisis.[1] Although there remain differences in one's definition of AI, depending on computational experience, AI within radiology generally refers to the automation of fundamental cognitive tasks that would normally require human intelligence.

While the principles of AI have been around since at least the 1950s, a lack of computational hardware and structured data meant that early iterations of AI could not surpass human performance.[2] Fast forward to the widespread adoption of deep learning, accessibility to graphical processing units and large repositories of annotated data, and it is now commonplace to see AI surpassing human performance in narrow radiological tasks, mainly involving image classification and object detection. Deep learning is the method by which an algorithm can 'learn' a set of features that reflect a hierarchy of structures within data.[3] It uses an artificial neural network that is loosely based on biological neurons of the human brain and has allowed algorithms to be successful in performing a number of perceptual tasks, which were previously not possible.

Clinical decision support and augmentation of workflow

Much of the initial AI product development focused on 'downstream' processes that involve using AI for detection and segmentation of anatomical structures, as well as the detection and quantification of a range of pathologies, eg intracranial haemorrhage, ischaemic stroke, primary brain tumours, cerebral metastases and abnormal white matter signal intensities.[4] Many of these previously clinical unmet use cases are now commercially available with end-to-end integration within existing radiology workflows. Zebra Medical Vision's (Shefayim, Israel) CE-marked solution screens unenhanced CT scans of the brain for intracranial haemorrhage and can automate the re-prioritisation of worklists for expedited reporting. Similarly, Aidoc (Tel Aviv, Israel) has CE-marked solutions for the detection of large vessel occlusion on intracranial CT angiograms. Adaptive re-prioritisation of worklists in real-time has tangible reductions in reporting times, ensuring the most critical patients can be identified and reported on first.

Taking the time to take the concept a step further, the widespread availability of mechanical thrombectomy for ischaemic stroke means 'door to groin' is now a key performance indicator. Although not currently available in the UK, Viz.ai (San Francisco, USA) is currently being used in the USA having recently announced Medicare reimbursement.[6] Viz LVO detects large vessel occlusion on intracranial CT angiograms, but also provides alerts to the entire clinical team including the interventional neuroradiologist, stroke physician and diagnostic radiologist, via the transfer of DICOM data through to smartphones in less than six minutes from imaging acquisition through secure mobile applications. Combined with its AI-enabled perfusion software Viz CTP, information regarding the ischaemic penumbra and infarct core can be established and aid clinical decisions.

While improving reporting times of neuroradiological studies is clearly of benefit, there is now a plethora of quantitative MRI AI solutions designed to improve the diagnostic value and accuracy of neuroradiological reports by removing reader biases. Solutions include icometrix's (Leuven, Belgium) icobrain product suite and CorTech Labs (San Diego, USA) NeuroQuant and LesionQuant. Accurate segmentation and volumetric measurements of cerebral microstructures can more accurately determine disease burden and track subtle longitudinal changes over time across a number of diseases including dementia, multiple sclerosis and epilepsy.

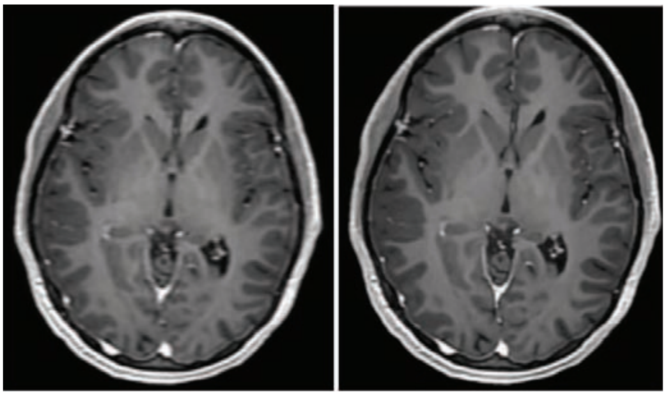

Figure 1
Axial low resolution T1W MRI (left). Axial super resolution T1W MRI of the same patient enhanced using SubtleMR software (right) with significant improvement in image quality while reducing acquisition time.

The clinical impact of invisible AI is not to be underestimated

While downstream clinical decision support AI solutions provided much of the early 'hype' of AI, it is perhaps the less saturated 'upstream' AI solutions in image acquisition and reconstruction that have an equal or even greater role to play within the field. Neuroradiology has always faced challenges with image acquisition and post processing, whether it be due to ionising radiation, prolonged acquisition times, contrast agents, or even poor image resolution. AI has the potential to tackle all of these issues, with fewer medicolegal risks and ethical considerations than AI-enabled clinical decision support tools.

The closure of elective MRI scanning during the height of the COVID-19 pandemic meant that the number of patients waiting longer than six weeks for an MRI scan was up to 15 times greater than at the start of 2020. While the natural reaction is to extend scanning hours to make up for the backlog, the rate limiting step to increasing scanner throughput will remain MRI acquisition times. Industry

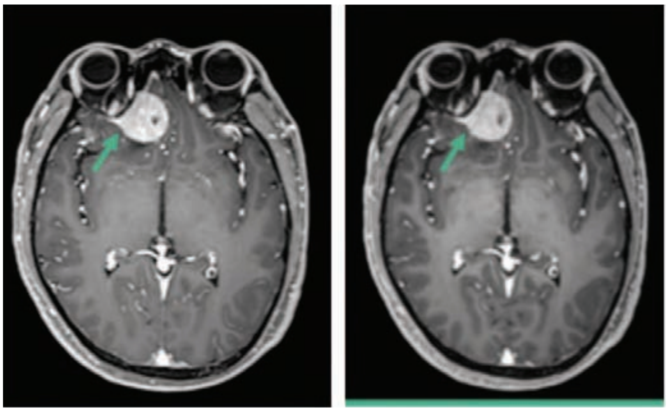

Figure 2

Full dose gadolinium 0.1mmol/kg (left) axial T1 post contrast. Low dose gadolinium 0.01mmol/kg (10%) post processed using SubtleGAD software does not show any reduction in diagnostic quality, having been acquired using only a fraction of the full gadolinium dose.

leaders in upstream imaging AI solutions, Subtle Medical Inc (Palo Alto, USA) realised AI's potential to optimise acquisition parameters with a view to achieve diagnostic quality images faster and with lower doses of contrast agents. Their CE-marked solution SubtleMR nullifies the long scan times required to achieve super resolution, by using AI to post process fast, low resolution T1-weighted acquired images into diagnostic super resolution images (**figure 1**). Not only does this reduce acquisition time and improve image quality, importantly it lends itself to a better patient experience and minimises the risks of movement artefact in non-compliant patients.

While gadolinium-based contrast agents have been a mainstay in MR imaging, there remain ongoing concerns with regards to nephrogenic systemic fibrosis, and the long-term effects of gadolinium deposition in the dentate nuclei and globus pallidus.[6] This is of particular concern in patient groups requiring serial follow-up using contrast-enhanced MRI. While reducing the gadolinium dose is one method of reducing the risk, the trade-off normally results in a non-diagnostic acquisition. Using innovative AI solutions, the team at Subtle Medical have managed to post process 10% low dose gadobenate dimeglumine (0.01mmol/kg) MRIs into full contrast dose 0.1mmol/kg quality images.[7] Although not yet CE-marked, the SubtleGAD algorithm learned the guided de-noising of the noisy contrast uptake extracted from the difference signal between low dose and zero dose MRIs, then combined them to synthesise a full dose contrast-enhanced MRI of complete diagnostic quality (**figure 2**).

It is clear that AI-driven solutions in neuroradiology are just starting to embed themselves within the complete radiological workflow from image acquisition, post processing to clinical decision support. Acceptance and adoption by the community, albeit with a critical eye, will ensure these AI-enabled innovations will translate to improved experiences and outcomes for patients and neuroradiologists in these challenging times.

References

1, *2018 Radiology workforce consensus www.rcr.ac.uk/system/files/publication/field_publication_files/clinical-radiology-uk-workforce-census-report-2018.pdf*

2, *Hosny A, Parmar C, Quackenbush J et al. Artificial intelligence in radiology. Nat Rev Cancer 2018;18(8):500-10. doi:10.1038/s41568-018-0016-5.*

3, *Chartrand G, Cheng P M, Vorontsov E et al. Deep learning: a primer for radiologists. Radiographics 2017;37(7):2113-31. doi: 10.1148/rg.2017170077. PMID: 29131760.*

4, *Zhu G, Jiang B, Tong L et al. Applications of deep learning to neuroimaging techniques. Front Neurol 2019;10:869. doi: 10.3389/fneur.2019.00869. PMID: 31474928; PMCID: PMC6702308.*

5, *Website: www.prnewswire.com/news-releases/vizai-granted-medicare-new-technology-add-on-payment-301123603.html*

6, *Kanda T, Nakai Y, Oba H et al. Gadolinium deposition in the brain. Magn Reson Imaging 2016;34(10):1346-50. doi: 10.1016/j.mri.2016.08.024. Epub 2016 Sep 8. PMID: 27613998.*

7, *Gong E, Pauly J M, Wintermark M, Zaharchuk G. Deep learning enables reduced gadolinium dose for contrast-enhanced brain MRI. J Magn Reson Imaging 2018;48(2):330-40. doi: 10.1002/jmri.25970. Epub 2018 Feb 13. PMID: 29437269.*