Could AI-Driven Acceleration Techniques be One Answer to the Issue of Environmental Sustainability in MRI?

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Background

Magnetic resonance imaging (MRI) plays a vital role in medical imaging, providing the high-resolution images that are crucial for accurate disease diagnosis and patient management. However, healthcare in general and imaging in particular have a considerable environmental impact: The global healthcare sector accounts for 4.4% of greenhouse gas (GHG) emissions, but here in Australia that figure is 7% [1]. A recent study found that pathology testing and diagnostic imaging in New South Wales, Australia's largest health system, contribute 9% of the carbon footprint from Australian healthcare [1]. As the healthcare industry seeks to reduce its carbon footprint, imaging technologies clearly have a vital role to play here, too.

MRI systems are highly energy-intensive [5]. This poses significant challenges for healthcare sustainability and environmental preservation. One way of addressing the energy issue in MRI is to use artificial intelligence – specifically, deep learning.

While deep learning applications can optimize multiple aspects of MRI operations, their ability to accelerate imaging protocols is especially relevant to sustainability. With advanced denoising techniques, deep learning maintains diagnostic image quality while significantly shortening the time required for each scan. Since faster scans use less energy, deep learning has the potential to minimize greenhouse gas emissions from MRI systems.

Impact of deep learning on scan times at our institution

We recently implemented Deep Resolve, an AI-powered, deep learning image-reconstruction technology from Siemens Healthineers, on our 3 Tesla MAGNETOM Vida system (Siemens Healthineers, Erlangen, Germany). At the time of writing, Deep Resolve has not yet been fully implemented across all MRI scanners in our multi-hospital network.

For the initial implementation, we targeted one of our frequently requested examinations on the MAGNETOM Vida system, to see where we could have the most impact in terms of time savings. To do so, we gathered data on all the MRI examinations performed on the system in 2023. This showed that we most commonly performed brain and spinal cord imaging for multiple sclerosis (MS) and demyelination pathologies. For this examination alone, Deep Resolve enabled us to achieve a 42% time saving, reducing the active scan time from 50 minutes to 29 minutes (Table 1) with comparable, and in some instances improved, image quality (Fig. 1).

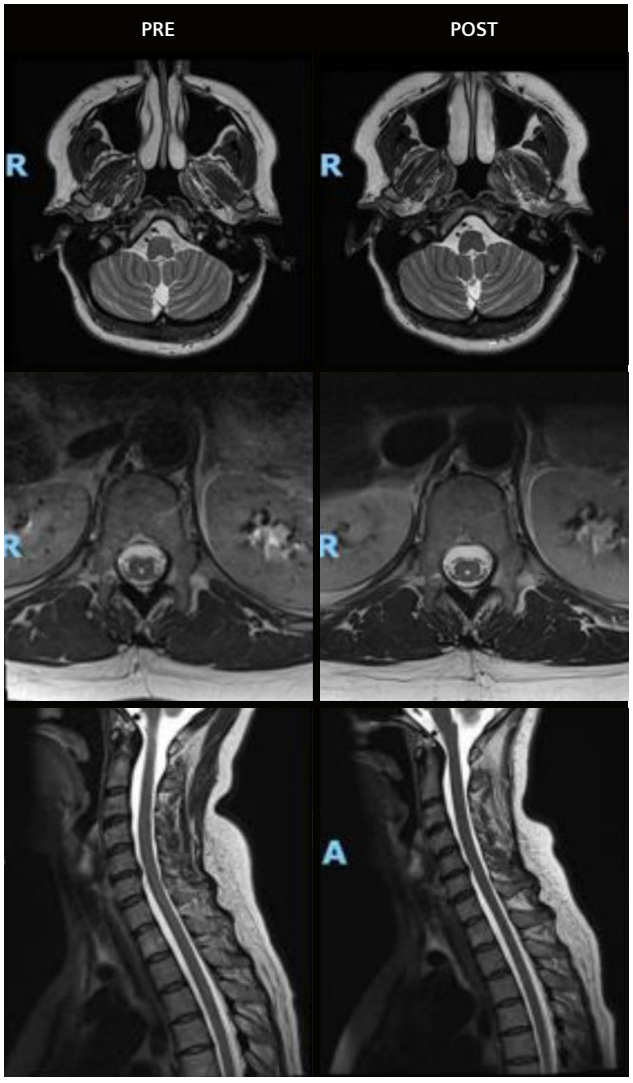
Our 3T MAGNETOM Vida is operational for 89.5 hours per week, from 7:30 a.m. to 10:00 p.m. Monday to Friday, and from 8:00 a.m. to 4:30 p.m. on Saturday and Sunday. Therefore, a 42% reduction in active scan time for one of our most frequent examinations effectively means a savings of 228 hours, or approximately 2.5 weeks, per year.

Number of exams in 2023	Pre-AI active scan time	Post-AI active scan time	Active scan time reduction per patient	Active scan time reduction per year (minutes)	Active scan time reduction per year (hours)
651 exams	50 min	29 min	21 min (42%)	13,671 min	228 hrs

Table 1: Retrospective analysis of 2023 data for Brain and spinal cord MRI.

The average power consumption of a 3T MAGNETOM Vida during active scanning is 23.4 kW [9]. Using this figure and our 2023 scan data numbers, the kWh required for active scanning in a brain and spinal cord examination is 12,675 kWh across the year. After implementing Deep Resolve on this protocol, the kWh required for active scanning declined to an extrapolated 7,363 kWh for one year. This reduces the average power consumption by 5,312 kWh per year. According to the Carbon intensity of electricity generation in 2023 this would be equivalent to 2.9 metric tons of carbon dioxide-equivalent emissions in Australia [10]. This equivalent to the carbon sequestered by planting and growing 48 tree seedlings for 10 years [11].

These rudimentary numbers are based only on active scanning energy consumption from a single examination after the implementation of Deep Resolve. Given that AI-driven reconstruction leads to some substantial time savings and if similar time savings were extrapolated out across other time-intensive MRI examinations, and across other scanners and sites, the impact on greenhouse gas emissions would speak for itself.



1 Brain and spinal cord images from a patient scanned for demyelination. Imaging was performed both before and after the introduction of AI software (Deep Resolve) from Siemens Healthineers. The left-hand images are before the introduction of Deep Resolve, and the right-hand images are after. Our aim was to achieve equal, if not better, image quality with the AI software.

Co-benefits

In addition, the shortened scan times enabled by Deep Resolve also reduce costs [5] and improve patient comfort [3]. They can increase diagnostic accuracy because faster scans may lead to less movement in patients who find it hard to lie still for long periods. They can also increase patient tolerance and compliance. Technologists benefit as well, with the potential for less stress at work as a result of having more capacity to handle urgent patients, and a reduction in the need for overtime. Furthermore, the newly created space in the schedule could be used to provide technologists with much-needed time for implant investigation, online mandatory training, and continuing professional development. This is what our organization is hoping to do once Deep Resolve has been fully implemented.

Summary

Deep learning technology is a new pathway to improved sustainability within MRI. By decreasing energy consumption and improving imaging efficiency, AI could be the game changer we need at this crucial time in the history of climate change. It also brings co-benefits in the form of lower operational costs, improved patient comfort and diagnostic accuracy, and scope to allocate resources and time more effectively for technologists.

As medical imaging and healthcare in general embrace the digital transformation, leveraging AI is a key cog in the larger strategy required for creating a more sustainable and efficient healthcare system. With AI continuing to develop and transform medical imaging, we must continue to think of ways to harness its potential for improving sustainability.

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