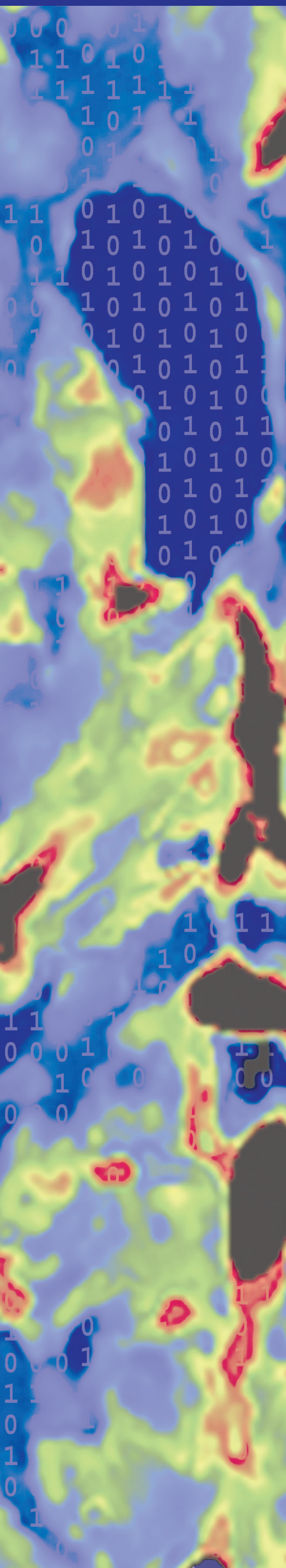

Artificial Intelligence and Medical Imaging: Image Acquisition and Reconstruction

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It is quickly becoming clear that new tools based on artificial intelligence (AI) can make significant, positive impacts on patient throughput, comfort, and safety. Whether these innovations arrive 'built in - on device' or from third party AI vendors will be interesting to watch, as benefits exist for each approach. Determining the return on financial investment for these AI-based imaging techniques is a critical challenge.

Computed Tomography (CT)

Over the last decade, iterative reconstruction (IR) has gradually replaced the filtered back projection (FBP) image reconstruction techniques employed by legacy CT systems. While the low computational requirements of FBP made fast reconstruction feasible with limited computing resources, FBP reconstruction relies on relatively high X-ray dosing to overcome higher (assumption- and error-driven) noise. Iterative reconstruction requires lower radiation doses than FBP, but IR produces an unquestionable alteration in image 'look' that some find objectionable as a result of a shift in the noise power spectrum.

Advanced model-based IR (MBIR) techniques (VEO, ASIR-V GE, IMR Philips) further reduce radiation dose requirements but deliver an appearance that varies even more from that of FBP, limiting universal acceptance among radiologists. Perhaps most important, both IR and MBIR do not completely emulate and preserve the (quantitative) HU behavior of FBP, creating additional diagnostic challenges.

To overcome these limitations, GE Healthcare and Canon Medical Systems have begun marketing FDA-cleared machine learning-based (ML) methods of image reconstruction in their CT scanners. GE's TrueFidelity and Canon's AiCE (Advanced intelligent Clear IQ Engine) are said to reduce radiation dose even further without adversely impacting the quality of diagnostic CT images. Leveraging ML techniques trained on traditional CT, these images maintain the appearance more familiar to interpreting physicians, preserving the quantitative integrity of FBP image reconstruction with no significant shift in the noise power spectrum. Their acceptance by the imaging community, therefore, may be limited only by the incremental cost of these reconstruction options.

Positron Emission Tomography (PET)

PET also benefits from AI/ML-based tools. Subtle Medical markets an FDA-cleared tool, SubtlePET, that reduces the number of counts necessary to reconstruct an image. A reduced count requirement can be leveraged to reduce the amount of radioactive tracer and/or lower the time spent at each bed position. A lower dose requirement is particularly helpful when imag-

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ing pediatric patients and those requiring PET imaging for long-term surveillance. The shorter acquisition time per bed position can improve patient comfort and increase scanner capacity, assuming sufficient prep room availability.

Magnetic Resonance Imaging (MRI)

Patients may find MRI studies stressful, with up to 30% suffering frank anxiety reactions. The best way to improve the patient experience is to reduce time spent on the scanner. MedicVision is marketing an ML-enhanced image space-based IR package that offers up to 30% reduction in scan time. Subtle Medical's FDA cleared, DL fueled SubtleMR also enhances MR scans and research suggests the capability to significantly shorten scan acquisitions. Their yet-to-be-cleared product, SubtleGAD, shows the potential to reduce contrast dose in research studies as well. For patients due to undergo serial MR examinations, as well as children, lower contrast doses could mitigate concerns about trace amounts of retained gadolinium.

In addition to the multiple opportunities for resolution-preserving noise reduction discussed above, Subtle's FDA-cleared SubtleMR directly enhances the resolution of MRI studies. GE Healthcare's MRI division, meanwhile, is preparing AIRecon (510K pending), a DL, k-space-based image reconstruction tool to increase image spatial resolution and boost acquisition speed by reducing noise. Canon's FDA-cleared AiCE, discussed above for CT imaging, is also being offered to reduce scan time and permit higher-resolution approaches to MR imaging.

AI should bring additional patient-focused benefits to MR imaging. Several entities are working on tools that will eliminate signal from motion on MR images. Eliminating motion can reduce the need for repeat scans which prolong the imaging process. MRI vendors are also marketing DL-based tools for automatic scanning coverage and angulation optimization, which should also lead to a more concise and less stressful (and more reproducible) imaging episode.

The Cost of Innovation

As one might expect, innovations like these come at a price. Third parties typically offer their AI products on a prescription basis with higher use volumes at lower incremental cost. Original equipment manufacturers (OEMs) usually build innovations into their latest models at a one-time cost, but in some cases they emulate the prescription model on both new and older units. Initially, the appeal of third-party tools seems greatest on older scanners in need of a boost in speed and quality. Ultimately OEMs may choose to partner with third-party vendors to package their solutions along with new scanner purchases.

To justify expenditures for these new AI-based tools, organizations must quantify return on investment (ROI) at the scanner. Shorter protocols could enable a shift from 45-minute to 30-minute scan slots, allowing more scans per day or shorter workdays with reduced staffing and overtime needs. We have found a direct correlation between table times and patient satisfaction, undoubtedly impacting referral patterns and possibly even reimbursement.

As we emerge from the COVID-19 crisis and the volume of imaging deferred during social distancing inevitably returns, additional benefits will come into play as more efficient image acquisition will leave more time to devote to the safe transition of exam rooms between patients.

In summary, AI techniques are increasingly prevalent throughout the healthcare enterprise. When employed in the process of image reconstruction and acquisition, ML-based techniques can have an enormous impact on throughput, patient comfort and safety.

Whether these innovations arrive 'built in - on device' or from third party AI vendors will be interesting to watch. Determining ROI is a critical challenge before these innovations will be widely adopted.