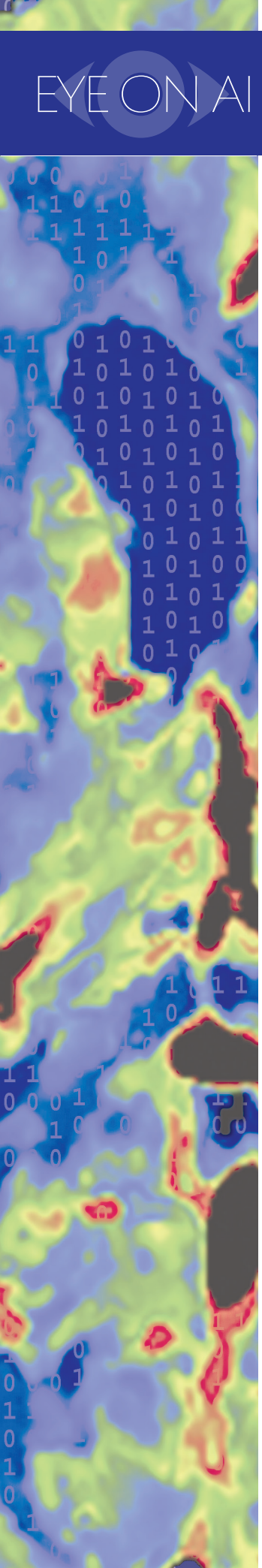

Enhancing Neuroimaging with Artificial Intelligence

Suzie Bash, MD

People traditionally think of artificial intelligence (AI) as a means of using computer-generated neural networks to mirror the intellectual thought processes of human beings. In reality, however, humans are not so interested in thought duplication; they are much more interested in thought augmentation.

We want computers to elevate and augment human capacity and improve efficiency. Computers are now sophisticated enough to quickly analyze large volumes of high dimensional data and recognize patterns. Computers are actually better than humans at pattern detection. Through deep learning algorithms, computers can be taught to answer questions that augment human capabilities. Deep learning (DL) is a form of machine learning (ML) employing convolutional neural networks, which has shown great potential in medical imaging applications. AI is the future not just of medicine, but of all occupational sectors because of its power to enhance efficiency, accuracy, value and quality.

The goal of many AI companies is to expand their narrow use products into broader comprehensive AI suites, which not only elevates the value of the software, but also makes them more marketable to end-users. AI tools are continuing to evolve and improve at a rapid pace and can be employed before, during, or after image acquisition.

Mining patient notes, improving billing, preventing no-shows

Before patients even enter the imaging suite, AI tools can mine electronic health records to extract key clinical notes and present them in a dashboard summary for the radiologist's review, such as IBM Watson Imaging Patient Synopsis (IBM, Cambridge, MA, distributed through Guerbet). RadNet's AI division has recently integrated the AI company NuLogix (Santa Monica, CA) which will have several roles, including improvements in billing. RadNet is also working with Philips on a project using ML to analyze and prevent "no shows."

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Accelerating acquisition, improving quality, lowering dose

AI tools can optimize quality by standardizing patient head angulation, reducing noise, and minimizing artifacts. Real-time patient motion correction is the goal of tools such as the (not yet FDA cleared) visual biofeedback application of FIRMM™ (Nous, St. Louis, MO). One of the most exciting current applications of AI for MRI and PET-CT image acquisition is the utilization of tools employing deep learning algorithms to markedly enhance image quality and reduce scan acquisition time, by as much as 75%, as with Subtle Medical's (Palo Alto, CA) FDA-cleared SubtleMR™ and SubtlePET™. Studies have shown that the shorter the scan, the higher patients rank their imaging experience. These tools also improve scanner efficiency and offer opportunities for better image quality. Canon has commercialized AiCE™ for both their CT and MR products providing the same potential benefits. Similarly, iQMR™, an FDA-cleared, vendor-agnostic ML boosted iterative reconstruction image-enhancement add-on from Medic Vision (Tirat Carmel, Israel), can achieve 40% faster MRI scanning with higher resolution. Medic Vision also has a SafeCT™ iterative reconstruction product which allows (up to 60%) dose reduction without compromising image quality. GE Healthcare has a deep learning AI product in the pipeline (510K pending) which leverages k-space data to sig-

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nificantly improve image quality and create the opportunity for significant scan time reduction. Subtle Medical is also developing a DL based tool to reduce gadolinium contrast dose (SubtleGAD™, not yet FDA approved) to only 10% of that typically required, while preserving the intensity of contrast enhancement, which is a promising product, particularly in light of known gadolinium deposition in the brain with repetitive contrast-enhanced MRI exams.

Flagging urgent findings, quantitative volumetric and metabolic analysis

AI tools are also being used by physicians post-acquisition. Among these are triage apps such as Aidoc's (Tel Aviv, Israel) FDA-cleared, "always on" technology that analyzes CT scans of the head and spine in the background, and then identifies the urgent acute findings (intracranial hemorrhage and cervical spine fractures) and flags these cases for expedited reading. This type of prioritization software reduces report turn-around time so the most critical patients can be identified and treated first. Other FDA-cleared AI tools such as icometrix' icobrain (Leuven, Belgium), maxQ Ai™ (Tel Aviv, Israel) and Zebra Medical (Providence, RI) can also identify (and for icobrain, quantify) intracranial hemorrhage.

Meanwhile, large vessel occlusions (LVOs) are being automatically identified with FDA-cleared tools like Viz.ai's Viz LVO™ (Tel Aviv, Israel) which not only flags the LVO on the CT angiogram (CTA), but also alerts the entire stroke team (neuroradiologist, interventional radiologist and neurologist) via transmission of pertinent DICOM images through a secure mobile app to their personal cellphones, with less than 6 minutes from acquisition to alarm notification. Additionally, Viz.ai's companion tool, Viz CTP™, can measure perfusion in affected areas of the brain. In the pipeline, Aidoc is shepherding a new ischemic stroke module (CE marked, FDA pending) to flag LVOs for faster treatment.

Quantitative volumetric MRI tools add diagnostic value, accuracy and efficiency. They assist in eliminating reader subjectivity and provide objective longitudinal assessment of disease. Products like NeuroQuant™ and LesionQuant™ (CorTechs Labs, San Diego, CA) and icobrain (icometrix, Leuven, Belgium), leverage machine learning to enhance segmentation. By calculating the volume of substructures of the brain (such as hippocampal atrophy in patients with dementia), these applications augment the evaluation of dementia, seizures, multiple sclerosis and brain trauma by highlighting statistically significant variations from an age and sex matched normative database. In patients with multiple sclerosis, the software calculates the volume of new, enlarging or shrinking plaques, overall plaque burden and interval change from prior studies. FDA cleared MIMneuro™ (MIM Software, Cleveland, OH) and 510K pending PETQuant™ (Cortechs Labs, San Diego, CA) aid in the quantitative interpretation of brain FDG PET and amyloid PET studies in patients with memory loss. The software aligns the PET images into a built-in atlas (MIM) or native patient brain (CorTechs) space, providing quantitation of standardized uptake values (SUVs) by anatomical region. The software also calculates the statistical significance of variations in regional metabolic activity or amyloid deposition by reference to a normative database, which helps establish whether a true neurodementia syndrome, such as Alzheimer's disease, is present.

AI applications are quickly becoming embedded in the fabric of advanced, state-of-the-art neuroimaging by creating value, enhancing quality and saving time. Transformational innovation through AI is actively expanding our human capabilities, unlocking the potential of digital technology and ultimately making a meaningful difference in our patients' lives.