WHITE PAPER

A precision health company

Improve Radiologist Productivity and Clinical Confidence when Reading Head CTs

Approximately 2.3 million people with traumatic brain injuries are seen annually in U.S. emergency departments. Approximately half of these patients receive a head CT to assist in diagnosis and treatment, and approximately 500,000 of these patients are uncooperative due to trauma, cervical spine collars, and/or altered mental state. These challenges often result in head positioning issues that create some level of head tilt or rotation during the scan. This in turn results in images that are inconsistently oriented both across patients and across time when follow-up scans are acquired of the same patient. All of these factors make it more difficult for a radiologist to interpret and quantify what they are reading.

Often the most challenging clinical cases have the greatest head positioning issues:

- Acute head trauma
- Hydrocephalus
- Hypertensive hemorrhage
- Brain tumors
- Stroke
- Aneurysmal rupture
- Neurosurgical post-operative cases
- Shunts and external ventricular drains (EVD)

Inconsistent image orientation results in a myriad of problems that affect patient care and clinical decision-making. Radiologists are often required to visually correct for head position inconsistencies as they scroll through an image series. The CT technologist may be tasked with manually realigning the studies, however their availability is unpredictable and the quality can vary depending upon their skill and expertise.

Radiologists are constantly tasked with analyzing and integrating more clinical information in the same amount of time, and are under increasing pressure to provide faster reads without sacrificing the quality of their clinical interpretation. As exam volumes and the size of imaging studies increase, it becomes clear that software tools that enable radiologists to more quickly digest this information have the potential to provide great clinical value. This is particularly true when such tools support the high level health system goals of improving clinical outcomes and reducing costs by enabling clinical teams to capture reproduceable quantitative information across the entire health system and share it quickly and easily with clinical staff.

The Impact of Improperly Aligned Head CT Scans

An American Medical Group Association compensation and productivity survey showed relative value unit (RVU) radiology productivity increases of 3.5% and 3.4% in 2015 and 2016. 10 years ago, radiologists interpreted one image every 20 seconds; today they read one image every three seconds.* This has led to radiologist burnout and negative impacts to clinical quality and patient outcomes. With this increased workload, radiologists are expected to be more productive while maintaining clinical accuracy. Access to reliable, accurate information, particularly for the most challenging and time sensitive clinical cases, is critical.

These challenges can be particularly acute in Emergency and Neurosurgical departments at Level 1 and Level 2 trauma centers. Physicians must balance these challenges across a high volume of challenging head trauma cases. In these settings, it is critical to continuously improve efficiency, eliminate unnecessary tasks, and improve clinical confidence. Radiologists need to provide specialists with accurate and quantitative measures of change that help them treat patients more quickly and effectively. The American College of Radiology's Imaging 3.0 paradigm encourages the radiology profession to add clinical value and contribute to improvements in the delivery of care. Rapid access to new forms of quantitative information can enable radiologists to provide higher quality service to their clinical colleagues.

Focusing solely on improving the productivity and effectiveness of the radiologist overlooks other important assets affected by inefficiencies created by challenging head CT scans. When CT Technologists are asked to manually realign or reformat a head CT study, their attention and time is diverted from their primary task of managing and scanning patients. This results in reduced patient throughput, reduced CT scanner utilization, and delays in treatment decisions. When diagnostic and clinical workflow is delayed due to ambiguous or incomplete clinical information, costs escalate and patient care suffers. The tolerance for these issues continues to diminish as the US health system shifts to pay for performance and other accountable care payment schemes.

Machine Learning Enables a Better Solution

Modern software and computers can process repetitive tasks faster, more accurately, and more consistently than humans. In healthcare, CAD software has been used for years to identify lesions and to automatically reformat imaging studies. The adoption of machine learning in medical imaging has the potential to increase the accuracy and performance of such software, facilitate the development of new applications, and improve the consistency of the output of such software.

Machine learning is a branch of computer science that teaches software how to perform a task or set of tasks from training data. In radiology applications, this may include detecting abnormalities, identifying and segmenting anatomical structures or pathologies within images, or classifying cases as normal vs abnormal along some clinical criteria. Often, this is achieved by exposing the software to hundreds if not millions of cases that include the desired output. In the case of reformatting head CT studies, machine learning can be used to build up a statistical dataset of optimally aligned images (a so-called anatomical atlas) to help teach the software to align new data along standardized anatomical planes such as the anterior commissure - posterior commissure (AC-PC) plane. Because the AC-PC line is a standard viewing plane in radiology, such reformats would be instantly recognizable and would facilitate rapid image review by a radiologist.

* http://www.rsna.org/News.aspx?id=22797

Improving the consistency and reproducibility of reformatted images along standard planes also improves the quality of subsequent quantitative analysis that software can perform on these images. For example, volumetric analysis of anatomical features or pathologies such as intracranial hemorrhage would benefit and could be quickly provided to the radiologist and the treating physician to aid decision-making. While some radiologists have expressed concerns that machine learning could potentially replace their work, the real opportunity for machine learning is to enable radiologists to apply their skills more efficiently and with greater confidence.

Automation is the Key

The value of integrating machine learning into new software tools is optimized when its input and output are seamlessly and automatically integrated into existing clinical workflow. Performance must be sufficiently rapid to ensure that new information generated by the software is available to the radiologist when they read the studies. Such software must process head CT studies directly from CT scanners without requiring technologist input, and rapidly output reformatted studies into the patients' folders on PACS. In this way both the technologist and radiologist are able to focus on their primary responsibilities and fully utilize the new clinical information, without any disruption to existing workflow.

> CT CoPilot improved radiologist productivity by 73%, when assessing for change in ventricular volume, without sacrificing accuracy.

Dr. Nikdokht Farid, Associate Professor of Radiology in the Neuroradiology division at the University of California, San Diego has come to appreciate the value of integrating machine learning tools into her practice. She has been using CT CoPilot, an automated machine learning program that automatically aligns source images along standardized anatomical planes. Studies performed at UC San Diego have shown that CT CoPilot can improve reader certainty by 23% when determining increased ventricular volume and by 14% when determining decreased ventricular volume. Related research showed that CT CoPilot reduced the average radiologist interpretation time by 73% when assessing for change in ventricular volume, without sacrificing clinical accuracy. "The integration of CT CoPilot into our daily clinical workflow has been extremely beneficial," Farid said. CT CoPilot enables radiologists to read scans faster and more accurately. Technologists also are more efficient, with more time for scanning and focusing on patients, as they are no longer realigning and reformatting scans manually.

Automation and standardization also enables reformatted studies to be consistently aligned over time to create subtraction maps, a clinical tool that improves the conspicuity of subtle changes that may not be readily visible. Rapid assessment of change can be a significant challenge and historically requires the radiologist or clinician to perform manual measurements with tools that are available on PACS. Replacing manual assessment with automatically generated subtraction maps saves clinicians time and can improve their confidence in what is being observed. At UCSD, the trauma and surgical teams have also benefitted from the subtraction images in the rapid assessment of ventricular volume. This enables real-time clinical and surgical management decisions to be made, even before a formal radiologic assessment is available. "They can quickly view the subtracted images and more confidently visualize changes in ventricular volume, which may inform treatment planning," Farid said.

Summary

As fee for service reimbursement is replaced with pay for performance and other outcome-based reimbursement schemes, healthcare providers must continue to adopt tools that enable their organizations to digest and manage vast amounts of clinical information. Machine learning software tools that seamlessly integrate into radiologist and clinical workflow offer a significant opportunity to increase efficiency and accuracy. Machine learning will continue to weave its way into applications that help identify pathology, quantify anatomical and volumetric changes, and provide the radiologist with information to increase their clinical confidence, in even the most challenging cases.

As long as CT remains a rapid and cost-effective method of diagnosing head trauma, intracranial hemorrhage, and a host of other neurological issues, consistent patient positioning will be a challenge. Powerful tools such as CT CoPilot that offer automated alignment, co-registration, and quantification will remain helpful to any trauma, neurosurgical and radiology department seeking to improve clinical confidence, productivity, and patient outcomes.

CT CoPilot™ is 510(k) cleared but is not yet commercially available.

HealthLytix