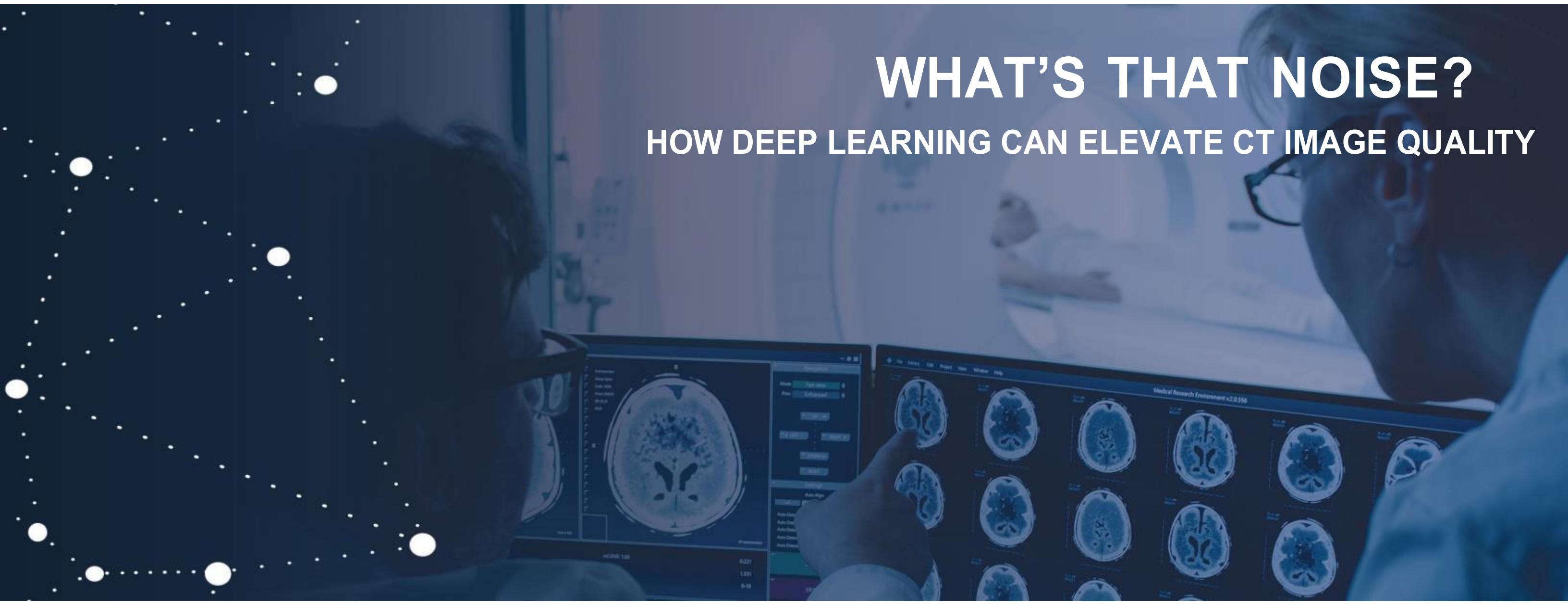
WHITE PAPER

PixelShine
Deep Learning Imaging Solutions



WHAT’S THAT NOISE?

HOW DEEP LEARNING CAN ELEVATE CT IMAGE QUALITY

Computed Tomography (CT) scanners have broad diagnostic application and are the most frequently used imaging modality for many different care pathways. This is because they are able to generate highly detailed images of bone, soft tissue, and vascular structures.

However, CT imaging exposes patients to high radiation dose, which has associated risks – especially for those more susceptible, such as:

- pediatric and obese patients
- patients who receive regular imaging to monitor chronic conditions
- patients in treatment procedures
- persons participating in lung cancer screening programs

The cumulative effect of exposure compounds the need to achieve the lowest per-scan patient dose possible. While low-dose CT imaging techniques exist, there is often a compromise that must be made in both image quality and cost. A direct and proportionate correlation can be drawn between CT image quality and radiation dose exposure. Lower-dose studies have higher image noise, which results in lower quality images, which are more difficult to analyze.

Imaging protocols and dose exposure can vary significantly across procedures and equipment. This is due to differences in capability and age, referrer ordering preferences, and imaging protocols – often rendering image quality as inconsistent. The result is inefficient reading workflow for radiologists, and worse, potential adverse clinical outcomes associated with missed findings.

Historically, older CT scanners deliver a higher dose to the patient compared to newer CT scanners that utilize Iterative Reconstruction (IR). Older scanners can sometimes be upgraded to IR in the field, depending on the model, at a substantial cost per scanner.

So, how can healthcare providers balance the requirement and desire for both high-quality, low-dose imaging while facing tight budgets and perhaps multiple CT scanners to address?

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CT IMAGING INNOVATION TIMELINE

To answer this question, it is important to remember how CT imaging has evolved over time and the various technologies in play. One of the earliest forms of CT image reconstruction, filtered back projection (FBP), remains the ‘gold standard’ in terms of image quality. This algorithm processes images quickly and generates high-quality images for higher-dose exams. However, this method is particularly susceptible to the dose/noise ratio paradox and therefore does not work well for low-dose procedures.

In the late 2000s, Iterative Reconstruction (IR) was introduced and is still the most used technique for improving the quality of lower-dose imaging studies. By applying various filters to CT images after they are acquired, IR reduces the ‘noise’ and enhances image quality of lower-dose procedures. However, while IR can provide a significant improvement over FBP in terms of reducing dose exposure, it can take substantially longer to process images and is prone to producing images with a waxy or blurry appearance if applied too strongly on low-dose studies. In addition, IR algorithms are only available on specific scanners manufactured by a vendor. Therefore, healthcare providers unable to upgrade all their CT scanners to the latest IR technology.

To account for these limitations, protocoling is the next line of defense for managing dose exposure. Image Wisely, a joint initiative between the ACR, RSNA, and ASRRT, provides guidelines, tools, and resources that help healthcare providers reduce the radiation exposure risk for patients. This includes optimizing CT dosage based on the modality, procedure, and anatomy involved.

Unfortunately, due to the complexity and effort required to define, implement, and monitor the many CT protocols that typically exist across a healthcare organization, this approach has not achieved universal success. Many institutions have hundreds or even thousands of CT protocols that are non-standardized amongst scanners, departments, and facilities. This creates a scenario in which the risk of unnecessary radiation dose exposure remains unnecessarily high.

DEEP LEARNING CAN IMPROVE IMAGE QUALITY AND FACILITATE DOSE REDUCTION

Deep Learning Reconstruction (DLR) is the next generation in CT image noise reduction techniques. DLR is a subset of Artificial Intelligence and Machine Learning, which quickly processes CT images, removes ‘noise,’ and produces good quality images.

DLR not only improves the quality of CT images acquired during typically low-dose procedures like lung screening and pediatric exams, and for other higher-risk categories such as oncology and obese patients. In addition, it can improve the image quality of ultra-low-dose abdominal, cardiac, and brain scans.

DOSE, IMAGE QUALITY, AND RADIOLOGIST PRODUCTIVITY

Variations in CT image quality cause increased strain on radiologists who typically read studies from many different scanners, as they must adjust their focus and process for each study they read. For images of lower quality, radiologists must spend more time carefully discerning between image ‘noise,’ normal anatomy, and potential findings. This can result in radiologist frustration and fatigue, reduced report turnaround times, and decreased productivity.

Standardizing and harmonizing image quality through protocoling can help improve radiologist productivity. However, this approach instead shifts inefficiencies upstream to technologists who must manually adjust modality settings according to each optimized procedure. Moreover, maintaining and enforcing adherence to consistent protocoling is a significant effort that often fails due to operational oversight and political challenges.

CLINICAL USE CASES

DLR can be universally applied across different CT scanners, imaging protocols, and anatomical region. The following are a few clinical examples of how DLR can substantially improve image quality of scans obtained at very low dose.

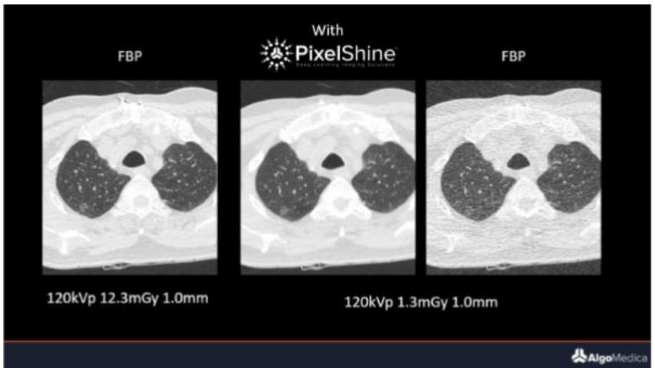

Figure 1: Low-Dose Lung Screening

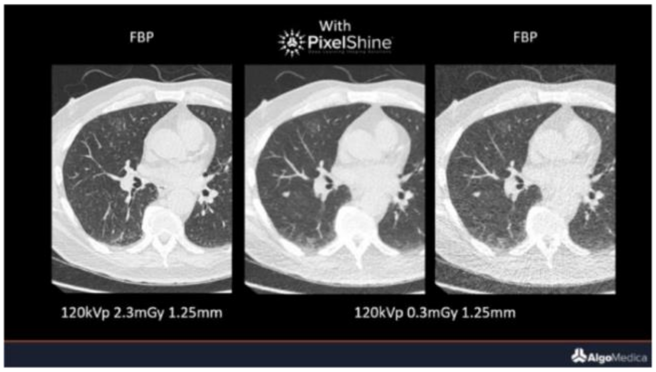

Figure 2: Normal Dose Lung Scan

LUNG SCREENING

Low-dose CT continues to be the only approved screening method for lung cancer according to the CDC[1]. It has been shown to reduce mortality and morbidity through early detection[2]. DLR has been shown to reduce the noise in low- and ultra-low-dose lung screening studies so that image quality is nearly equivalent to the standard-dose FBP[3]..

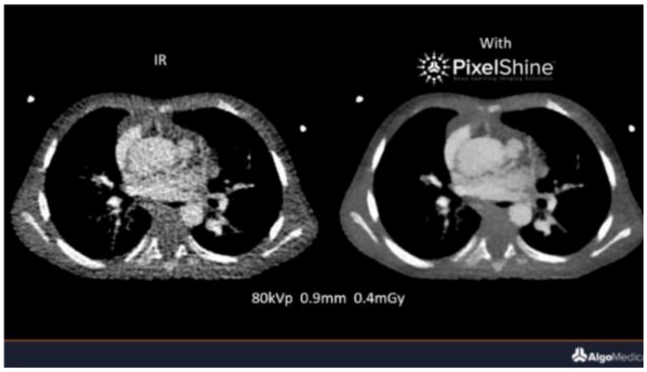

Figure 3: Pediatric Abdominal Scan

References:

[1] https://www.cdc.gov/cancer/lung/basic_info/screening.htm
[2] https://journal.chestnet.org/article/S0012-3692(18)30094-1/fulltext
[3] UVA Health Case study
[4] https://www.ncbi.nlm.nih.gov/pmc/articles/PMC9326759/

PEDIATRIC

Because children’s cells are rapidly reproducing, the risk from the potential carcinogenic effects of radiation exposure is increased for pediatric patients. Therefore, pediatric studies are always acquired at lower dose, and health care providers are burdened with the risk of accepting low-quality diagnostic images. These trade-offs are minimized with DLR, as it dramatically improves the ability to deliver, thin-slice images at the enhanced quality[4].

OBESE PATIENTS

Higher radiation dose is typically required to obtain viable image quality when imaging obese patients – and even then, the resulting images are often of very noisy and poor quality. DLR is also able to significantly improve the quality of standard-dose CT images of an obese patient and reduces the likelihood of a repeat scan.

Figure 4: Abdominal Scan of an Obese Patient

OTHER ANATOMIES (ABDOMINAL, CARDIAC, BRAIN)

Diagnosing many abdominal, cardiac, and brain conditions requires thin-slice images with high contrast and good conspicuity of fine details. Therefore, these exams are typically performed at higher radiation dose levels. Health care providers concerned for patient safety are always exploring ways to reduce CT radiation dose in the spirit of ALARA. One of the challenges they face while reducing dose is deterioration of image quality due to increased noise.

Figure 5: Abdominal Scan

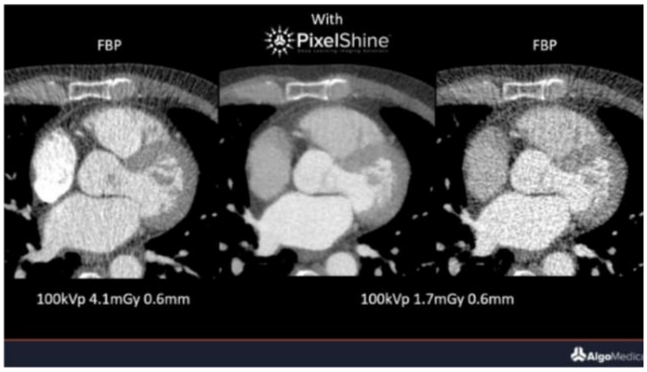

Figure 6: Cardiac Scan

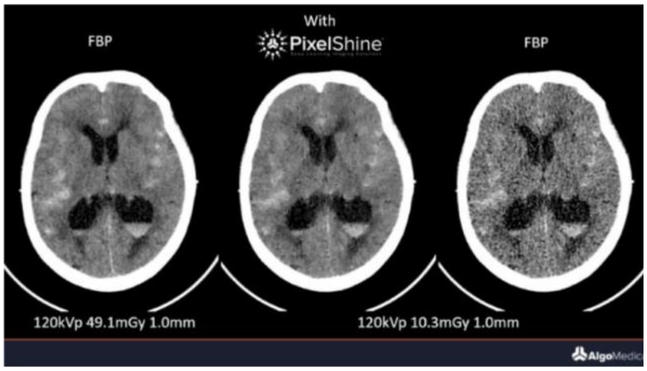

Figure 7: Brain Scan

ACHIEVE THE HIGH QUALITY CT IMAGING

Obtaining diagnostic quality images from the lowest possible dose images remains a top priority in medical imaging, especially for those patients in higher risk categories.
However, image quality and clinical outcomes cannot be compromised as a result. Adhering to the dose exposure guidelines advocated by Image Wisely and the ACR and RSNA guidelines, while ensuring radiologists receive images that are of a consistently high diagnostic quality, calls for an evolution in the way CT images are processed.

The only vendor agnostic CT noise reduction solution to leverage DLR is PixelShine® by AlgoMedica**. It provides an opportunity for imaging facilities to enhance the image quality of universally reduced-dose protocols which result in increased image noise. PixelShine reduces noise on the images coming from any CT scanner that communicates via DICOM. Because PixelShine® can quickly* and consistently reduce image noise on a CT image, independent of clinical application, care providers can obtain high quality CT scans. This may reduce the need for specialized low-dose protocols, simplify technologist workflow and enable a standardization of CT image quality across installed CT scanners.

Until now, reducing CT image noise required a combination of cumbersome protocoling adjustments and costly capital equipment replacement – both of which are impractical or unfeasible for busy, budget-constrained care providers. As a vendor agnostic solution**, PixelShine® can communicate with new and older CT scanners via the DICOM standard. In addition, the ability of PixelShine to reduce image noise in older and refurbished CT scanners has the potential to extend their useful life cycle. With PixelShine®, leading imaging centers and care providers no longer must compromise – they can reduce CT image noise while maintaining good quality

* Pixelshine performance may be affected by different CT image reconstruction methods that are built into CT scanners.

** As long as minimum system functional requirements are met.

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