AbstractID: 6838 Title: Instrumentation noise equivalent exposure (INEE) and the effect of detector blurring and image post-process smoothing: A simulation study

Purpose: To investigate the behavior of Instrumentation-Noise-Equivalent Exposure (INEE) when there is detector blurring and image post-process smoothing.

Method and Materials: INEE is the exposure at which detected quantum noise and instrumentation noise are equal, and below which the system becomes instrumentation noise limited. In order to understand the effect of detector blurring and post-process smoothing on the determination of INEE, Poisson-distributed random numbers (representing input x-ray quanta per pixel) were generated that simulate an ideal input x-ray image pattern. Blurring functions were simulated by Gaussian point-spread functions with different full-width-half-maxima (FWHM), defined in a 15 pixel x 15 pixel kernel. The reference pixel-size and x-ray fluence were selected following a set of measurements on a custom Microangiographic detector (43 μm square-image-pixels in 1024x1024 pixel matrix). A two-dimensional discrete convolution of the Poisson-distributed image with the Gaussian blurring function results in an image with reduced total-noise, but constant signal. The instrumentation-noise was simulated by an additive constant-variance and zero-mean noise. Addition of instrumentation noise after the blurring process simulates the detector-blurring case, whereas addition before the blurring process represents the image-post-process smoothing. This study assumed that the system has no secondary-quantum-sink and follows Poisson statistics throughout the imaging-chain. INEE was determined by calculating the signal-to-noise ratio (SNR) over a range of input exposures, and analyzed as a function of Gaussian-width and additive-noise levels.

Results: The square-root of INEE is shown to increase linearly with detector-Gaussian-blur width, but is shown to be independent of image-post-process smoothing. For this particular study, a one-pixel increase in FWHM of the blurring function resulted in 1.5x higher output SNR.

Conclusion: A simple simulation study was presented to demonstrate that the SNR-based practical measurement of INEE is independent of image-post-process smoothing in digital x-ray imaging systems.

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