AbstractID: 11765 Title: Anatomical Power Spectrum and Detectability: An Analytical and Experimental Basis

Purpose: Superposition of anatomical clutter in medical images is known to degrade detectability of underlying structures. This paper investigates background power spectrum (PS) in tomosynthesis and cone-beam CT (CBCT) in a manner that is general to various applications (e.g., breast and chest imaging) and allows analysis of generalized noise-equivalent quanta (GNEQ) and task-specific detectability.

Methods: An analytical basis for physical phantom design was established from principles of self-similarity and fractal dimension. Random arrangements of equal volumes of spheres were found to present power-law noise comparable to that of, for example, breast or chest imaging. Rectangular and cylindrical phantoms containing spheres of various diameter (3-16 mm) were configured on an experimental bench for tomosynthesis and CBCT. Background PS was analyzed as a function of orbital extent, ranging from $\sim 10^{o}$-360^{o}. Results were fit to the empirical form K/f^b and incorporated in the GNEQ to investigate detectability versus tomosynthesis arc, imaging task, and dose.

Results: Clutter phantoms based on self-similar collections of spheres provided background PS described well by power-law noise. 3D background PS were highly asymmetric, subtending the tomosynthesis arc in the Fourier domain and scales with the number of backprojected views. Analysis of the fully 3D background PS yields K and b that vary with tomosynthesis angle in a manner consistent with expectations, is distinct from that previously analyzed in 2D slices, and highlights the effect of orbital extent on 3D detectability. Analysis of GNEQ identified total arc and dose required to achieve a given level of detectability, depending on the imaging task.

Conclusions: An analytical basis drawn from fractal theory guided phantom design providing power-law noise. Analysis of background PS, GNEQ, and detectability index over a broad range of system configurations provided a general basis pertinent to modality-specific systems, such as breast and chest tomosynthesis and CBCT.