AbstractID: 7354 Title: Investigation of Fourier-based, hypothesis-testing detection and discrimination tasks in dual-energy imaging

Purpose: To relate theoretical descriptions of detectability index to imaging performance as assessed by real observers for a variety of detection and discrimination tasks. Dual-energy (DE) imaging provided a foundation for the research, incorporating a variety of decomposition techniques that significantly affect the noise-equivalent quanta (NEQ).

Method and Materials: The NEQ was derived using cascaded systems analysis, extended to DE imaging with a flat-panel detector. Three idealized task functions were considered: sphere detection, shape discrimination (sphere vs. disk), and texture discrimination (uniform vs. crenellated disk). Detectability index was derived by integrating the task function over the NEQ. These idealized tasks were physically emulated with a chest phantom. DE images were acquired over a range of conditions and noise-reduction techniques, and the performance of real observers was assessed in rank-order and alternative-forced-choice (AFC) tests. The degree to which theoretical detectability index correlated to human observer performance was investigated.

Results: Decomposition technique profoundly affected the NEQ. Theoretical detectability index agreed qualitatively with human observers. In DE soft-tissue images, noise reduction (e.g. anti-correlated noise reduction) had a minor effect on sphere detection, but a significant effect on shape and texture discrimination tasks, consistent with a factor of ~2 increase in detectability. In DE bone-only images, noise reduction improved the detectability index for all tasks, particularly for detection of small spheres and texture discrimination. The results were consistent with phantom images where, for example, a 1.6 mm sphere became conspicuous (A_z~1.0) upon application of simple-smoothing on the high-kVp image.

Conclusions: Analysis of DE imaging performance provided a useful probe of the complicated interplay between frequency-dependent NEQ and various imaging tasks, evident in both theoretical and real observer studies. The results provide initial validation that theoretically derived detectability index represents a meaningful surrogate for observer performance and is a useful objective function for system optimization.