AbstractID: 3169 Title: Task-Based Optimization of Dual-Energy Imaging Systems using Generalized NEQ

Purpose: Dual-energy (DE) imaging is a promising advanced application of flat-panel detectors (FPDs) for early detection of lung cancer. This paper investigates the performance of FPD-based DE imaging systems by extending descriptions of generalized detective quantum efficiency (GDQE) and noise-equivalent quanta (GNEQ) to a task-based optimization of system design, image acquisition, and reconstruction.

Method and Materials: This investigation incorporates anatomical noise into traditional descriptions of DQE and NEQ to yield the GNEQ for DE imaging systems. Imaging performance was calculated using cascaded systems analysis and combined with anatomical noise measured and modeled as 1/*f* noise. Calculations of GNEQ were combined with Fourier descriptions of imaging task to yield the detectability index, *d'*, taken as an objective function for optimization of DE image reconstruction (tissue cancellation), kVp, added filtration, and allocation of dose between image pairs.

Results: Analysis of GNEQ reveals a tradeoff between increased quantum noise and reduced anatomical noise in DE imaging systems. Optimal DE image reconstruction (i.e., selection of tissue cancellation parameter, w_t) was found to exhibit moderate task dependence, ranging from w_t=0.49 to 0.44 for gaussian detection and discrimination tasks, respectively. Optimal kVp pairs were identified as a function of imaging dose – e.g., (90 / 150 kVp) at high dose (1 mR), decreasing to (60 / 120 kVp) at low dose (10 uR). The analysis quantifies the potential improvement in performance associated with addition of high-Z filters (e.g., Cu, Ce, and Ta). For fixed total entrance dose, optimal allocation of dose between high- and low-kVp images depends on the imaging task, highlighting the tradeoff between quantum and anatomical noise.

Conclusions: Experimental and theoretical analysis of GNEQ and task-based detectability index provides a fundamental understanding of the factors governing DE imaging performance and offers a powerful methodology for optimization of system design and image acquisition.