AbstractID: 4928 Title: Cascaded Systems Analysis of Noise Reduction Algorithms for Dual-Energy Imaging

Purpose: While dual-energy (DE) imaging provides increased nodule conspicuity in soft-tissue images and greater calcification visualization in bone-only images, DE image decomposition amplifies noise present in the projection data. This paper extends task-based cascaded systems analysis (CSA) to include a variety of DE noise reduction algorithms, offering a general analytical approach to optimizing DE imaging performance.

Method and Materials: Two noise reduction algorithms [simple-smoothing of the high-energy image (SSH) and anti-correlated noise reduction (ACNR)] were incorporated into CSA models for DE imaging to describe the DE modulation transfer function (MTF^{DE}), noise-power spectrum (NPS^{DE}), and noise equivalent quanta (NEQ^{DE}). The MTF^{DE} and NPS^{DE} were measured using standard edge-spread function and flood-field techniques adapted to DE imaging (with noise-reduction processing) and compared to theoretical results. The MTF^{DE} and NPS^{DE} were combined to yield the NEQ^{DE} and integrated with a spatial-frequency-dependent task function to provide a detectability index for evaluation of imaging performance using standard, SSH, and ACNR image decompositions.

Results: The MTF^{DE} and NPS^{DE} calculated using CSA agreed well with measurements. Detectability index provided an objective performance metric for identifying superior noise reduction algorithms under conditions of varying kVp, dose, and imaging task. For example, the DE detectability index for a delta-function detection task in the soft-tissue image was by far greatest for the ACNR algorithm, whereas SSH performed best for the bone-only image. A gaussian detection task, on the other hand, indicated superior performance for the ACNR algorithm for both soft-tissue and bone-only images.

Conclusions: Extension of CSA to include the influence of DE noise-reduction algorithms such as SSH and ACNR offers a powerful guide to system optimization. The general, analytical approach provides an objective means of selecting superior noise-reduction algorithms and “tuning” the parameters therein in a manner that weighs spatial resolution and noise in relation to the imaging task.