AbstractID: 4186 Title: Taking Image Science to Task in Advanced X-ray Imaging Modalities

With the development of high-performance digital x-ray imaging technologies such as flat-panel detectors (FPDs) comes the realization that their most significant impact may not be as a replacement for existing radiographic and fluoroscopic technologies, but in the ability to support a host of novel, advanced imaging modalities. Concurrent with the development of FPDs over the 1990s was the widespread adoption of practical, Fourier-based imaging performance metrology – described experimentally by the MTF, NPS, DQE, and NEQ and theoretically by linear cascaded systems analysis (CSA). Just as the application of CSA helped to illuminate the potential performance of FPDs in radiography and fluoroscopy, the extension of such methodology to advanced imaging modalities, such as dual-energy imaging, tomosynthesis, and cone-beam CT, promises to augment their development. One conclusion becomes immediately clear: optimization of radiographic performance alone is insufficient, and a theoretical understanding of the image formation processes appropriate to each modality is essential to understanding system performance. Even when the modality amounts to a series of deterministic image processing steps – e.g., filtered backprojection – CSA uncovers a complicated interplay between each step in the imaging chain. Thus, just as FPDs rise to the call of numerous advanced applications, image science must rise to the challenge of quantifying imaging performance in these advanced modalities. Factors being incorporated in CSA modeling include: x-ray scatter (system-level descriptions of the DQE); image lag (fluoroscopy and other real-time modalities); anatomical background "noise"; material decomposition processing (dual-energy imaging); and selection of reconstruction filters and voxel size (tomosynthesis and cone-beam CT). Furthermore, it is becoming increasingly clear that description of detector performance alone is only part of the story, and extension of NEQ metrology to include the objects of interest – i.e., the imaging task – is an important aspect of system optimization. By incorporating idealized, spatial-frequency-dependent descriptions of the imaging task with the NEQ, metrics of detectability provide an objective function for imaging system optimization and potentially begin to bridge the gap between Fourier-based descriptions of detector performance with observer-based descriptions of image quality.

Educational Objectives:

1. Review the application of cascaded systems analysis (CSA) to FPD imaging performance in radiography and fluoroscopy.
2. Understand "generalized" descriptions of NEQ, including the effects of x-ray scatter, image lag, and anatomical background noise.
3. Discuss a number of advanced applications of FPDs – including dual-energy imaging, tomosynthesis, and cone-beam CT – and understand the application of CSA to describing imaging performance in each case.
4. Examine task-dependent descriptions of imaging performance through incorporation of idealized task functions with the NEQ to yield measures of detectability.