AbstractID: 13251 Title: Predicting Noise and Resolution Properties in Tomosynthesis with Statistical Image Reconstruction

Purpose: The development of tomosynthesis imaging systems benefits significantly from a fundamental understanding of noise and resolution, and recent developments point to the importance of statistical reconstruction. However, the ability to predict imaging performance has been limited by the lack of a closed-form reconstruction and object-dependent, spatially-variant results. This work overcomes such barriers though closed-form approximation of local image properties about the solution to penalized-likelihood objectives. We incorporate advanced system noise and forward projection models to establish a theoretical basis for predicting imaging performance in tomosynthesis.

Methods: Based on previous work general to tomography [Fessler 1996], we derive high-fidelity approximations of the local impulse response, covariance function, and noise-power spectrum (NPS) in x-ray tomosynthesis. The prediction method does not rely on explicit iterative reconstructions of projection data and includes a general framework for system noise based on cascaded systems analysis of the detection process. Forward models have been developed for both the prediction model and the penalized-likelihood reconstruction algorithms used to experimentally validate the results.

Results: The covariance and NPS in a phantom study included: 1) the approximate prediction approach; and 2) a brute force approach based on iterative reconstruction of ensemble data. Excellent agreement was observed between the two methods. The predictor approach accurately captured the spatially-variant noise and resolution properties using orders of magnitude less computation time and represents the first application of such a model in tomosynthesis. The results are applied across a broad range of imaging techniques, including orbital angle, number of projections, and dose.

Conclusions: Closed-form predictors of noise and resolution in tomosynthesis by statistical image reconstruction have been developed and validated in comparison to measurement. The approach provides a new theoretical basis for performance characterization in spatially-variant systems and a tool for optimizing image quality and system design.

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