AbstractID: 9249 Title: Cascaded Systems Analysis of the 3D NEQ of Cone-Beam CT: Investigation of Voxel Size in Relation to 3D Noise Aliasing

Purpose:
A model is presented for calculating the 3D NEQ in cone-beam CT (CBCT) to allow quantitative investigation of tradeoffs in image quality associated with acquisition and reconstruction techniques. The model is validated against experiment and employed to understand the effects of voxel size on NEQ, specifically analyzing the differences between voxel averaging (in the 3D image) and pixel binning (on the detector).

Methods:
The 3D NEQ for CBCT was modeled using cascaded systems analysis. Models for the 2D MTF and NPS were extended to describe the process of 3D reconstruction to yield a 3D NEQ. To examine the specific question of voxel size, binning of detector pixels was described as an aperture / sampling process in the 2D projection domain, while slice averaging was described as an aperture / sampling process in the 3D domain. Analysis was performed across a range of conditions to examine tradeoffs in NEQ.

Results:
The model demonstrates excellent agreement with measurements across a broad range of conditions. The NEQ (particularly at high spatial frequency) depends strongly on the binning / sampling method due to NPS aliasing in both the projection and reconstruction domains. For larger slice thickness, binning of detector rows gives superior NEQ compared to slice averaging. Conversely, for increased axial voxel size, averaging voxels in the 3D domain is superior to 2D pixel binning. The complicated interplay between longitudinal and axial voxel size is rendered clear by the theoretical model.

Conclusions:
These results illustrate the value of 3D noise modeling in CBCT. The NEQ is shown to depend on noise aliasing effects that depend on the choice of binning / sampling of detector pixels and image voxels. This work helps to identify techniques that maximize NEQ by considering tradeoffs between spatial resolution, noise, and aliasing effects.