

Purpose: To analyze the stationarity of 3D x-ray cone-beam computed tomography (CBCT) through spatial and frequency domain descriptions of noise. Such analysis of the stationarity assumption is an essential component of task-based assessment of CBCT imaging performance.

Method and Materials: Three objects (air, water cylinder + bowtie filter, and water cylinder only) were imaged using a CBCT benchtop and the Feldkamp algorithm for 3D filtered backprojection. Noise-only 3D images were analyzed from the difference of two CBCT volumes under the three conditions. In the spatial domain, noise stationarity was analyzed in terms of variance maps, and in the frequency domain, in terms of the covariance matrix of the Fourier coefficients – of which the diagonal is the noise-power spectrum (NPS). For a stationary random process, the Fourier covariance matrix (FCM) is diagonal and the same at every location in the image.

Results: The three experimental conditions affected the degree of stationarity: air (highest stationarity), water+bowtie, water cylinder (least stationary). This rank order was consistent in terms of variance maps and the NPS. The off-diagonal elements of the FCM were non-negligible in comparison to the NPS and believed to have measurable effect on detectability.

Conclusion: The degree of non-stationarity in CBCT can be controlled experimentally and analyzed through both spatial and frequency domain techniques. From a practical standpoint of system design and evaluation, the findings suggest strategies for meaningful CBCT noise and NPS analysis. Model observer analysis should assess the validity of the stationarity assumption, recognizing its potential effect on task performance.