IMAGE QUALITY LIMITATIONS IMPOSED ON DISCRETE CT SYSTEMS BY NOISE-POWER ANOMALIES AND SAMPLING APERTURE MISMATCHES

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Understanding the characteristics of CT image noise is crucial to defining image quality figures-of-merit, especially for low contrast detectability and optimum dose utilization in CT imaging. This work investigates the four discrete samplings necessary for an actual non-continuum CT reconstruction and their effect on the information capacity, noise correlation behavior, and noise-limited detectability properties of CT images. We examine the process of discrete reconstruction, and outline the theoretical background necessary for interpreting the experimental noise behavior and image quality results. We present and analyze experimental CT data, both computer simulated for an ideal, but noisy, CT scanner and actual machine data for both the EMI CT-5005 and GE CT/T-8800 scanners.

We discuss the benefits and limitations of measuring the total system modulation transfer function using the point response and edge response methods, and present results of these analysis methods for both the simulated and actual CT systems. We quantitate the correlated noise properties of simulated and actual CT images determined by noise power and noise autocorrelation analysis, and show significant low and high frequency noise power anomalies due to mismatching the convolution-filter and pixel samplings. We present our experimental results for the noise averaging behavior of both simulated and actual CT noise images for both a square, and a pyramidal noise averaging aperture function. We also calculate the contrast-detail behavior based upon experimentally derived noise power spectra and total system modulation transfer function. We illustrate here how the phenomena of noise-aliasing, not previously considered, can seriously compromise image quality figures-of-merit validly derived for the continuum case. Finally, we present a protocol for the determination of dose utilization and detectability figures-of-merit which are sensitive to hardware and software artifact, and which will allow direct objective intercomparison between CT imaging systems.