Abstract

The performance of the X-ray detector has a significant impact on CT imaging. In the manufacturer environment, detector performance characterization includes a comprehensive set of tests for uniformity, sensitivity, maximum linear dose, spatial resolution, temporal resolution, lag and ghosting, efficiency, and noise performance. For photon-counting detectors (PCDs), additional evaluations of deadtime, energy response, and energy-threshold accuracy and dispersion are also required. In the clinical environment, however, acceptance testing and routine quality assurance of CT scanners focus primarily on overall image quality and on other scanner components, including tube output, laser alignment, and table position and motion. Little effort, if any, is devoted to isolating and characterizing detector performance itself. In light of conventional detector characterization methods, this gap arises largely from the limited control over and accessibility to clinical scanners imposed by the vendor. The most significant limitation is that raw detector counts and projection images are generally unavailable to clinical end users without vendor collaboration. Instead, the available data are reconstructed DICOM images that have already undergone multiple proprietary preprocessing and reconstruction steps. In addition, for PCD-CT systems, the detector energy thresholds are fixed, which further complicates characterization of detector energy response. Moreover, many clinical users may not be familiar with the existence or use of certain scanner functions, such as stationary-gantry acquisition, the ability to acquire energy-bin images, or the ability to manipulate pre-reconstruction correction settings in the Expert Scan mode of the Siemens NAEOTOM Alpha scanner. This work aims to develop a framework for detector performance characterization in clinical CT scanners without requiring access to raw counts, threshold control, or other proprietary information such as the reconstruction method, reconstruction filter, or preprocessing corrections. The proposed methods estimate detector performance from scanner-reconstructed DICOM images and use novel experimental designs or processing techniques to exclude non-intrinsic detector factors. The detector metrics successfully retrieved include detector modulation transfer function (MTF), detector detective quantum efficiency (DQE), and, for PCD-CT systems, detector deadtime and spectral response function (SRF).