Spectral distortion correction for photon-counting x-ray detectors

Introduction: Spectral distortions induced by pulse pileup, charge-sharing and other artifacts associated with photon-counting detectors lead to significant challenges for applying the quantitative material decomposition method in spectral CT. An image-based spectrum distortion correction technique was investigated. This technique requires a simple calibration process and the simulated incident x-ray spectrum.

Methods: Experiments were performed on a Cadmium-Zinc-Telluride (CZT) photon-counting detector with five energy thresholds. BR12 phantoms of various thicknesses were used for calibration. The dependence of the detected counts on the calibration thickness is measured for each energy bin. At the same time, the expected counts at the corresponding calibration thickness were simulated with a tungsten anode spectral model using the interpolating polynomials (TASMIP) code for an ideal detector. Thus, for ith energy bin, the calibration function hi can be obtained, which translate the measured counts into simulated ones. The image measured for an unknown sample can then be corrected by applying the calibration function hi to each pixel, forming a new image that is free of spectral distortion.

Results: The measured and the simulated x-ray spectra at 100 kVp are shown in Fig. 1. The energy thresholds of the five energy bins are noted by dashed lines. Significant distortions can be observed in the measured spectrum. The raw and the spectral distortion corrected counts for five energy bins are compared to the simulated values for 48.8 mm PMMA phantom in Fig. 2. The implementation of the spectral distortion correction leads to a good agreement between the corrected and the simulated counts. In Fig. 3, the volumetric fractions of the water, lipid, and protein contents derived from dual-energy imaging of the three-material decomposition phantom are presented. The proposed correction method significantly reduced the relative RMS error from 53.4% to 6.8%.

Conclusion: We have developed a method which can effectively correct the pulse pile-up and other artifacts in the spectrum recorded with a photon-counting detector. The implementation of the proposed method is expected to improve the accuracy in material decomposition for spectral CT applications.

REFERENCES