Accurate energy-based scatter correction in 3D list-mode PET

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Objectives: We present a novel scatter correction approach using the energy of individual photons detected in 3D list-mode TOF-PET and compare its accuracy to single scatter correction.

Methods: Energy-based scatter correction in list-mode TOF-PET offers an alternative to traditional model-based scatter corrections, that allows 3D estimation of scatter precluding the need of estimating a scatter sinogram. First, energy spectra of scattered and primary single photons were estimated using constrained spectral factor analysis (SFA) for different angular sectors of the scanner. Next, these spectra were used to compute the probability density functions of primary and scattered photons energies. Finally, these probabilities were incorporated in two MLEM update equations to jointly reconstruct scatter and primary images. We assessed the accuracy of our method (SFA-MLEM) in Monte Carlo simulations of the TF-Gemini and a cylindrical torso phantom. We compared contrasts obtained with SFA-MLEM to those with single scatter correction (SS) and a method combining both approaches.

Results: The estimation error of simulated spectra was 7% with SFA. Contrasts were 1.89 (ref:2), 3.71 (ref:4) and 0.21 (cold) with SFA-MLEM and 1.91, 3.76 and 0.25 with SS/tails fitting. Incorporating the energy information in the SS correction improved the accuracy of estimated contrasts from 1.69, 3.63 and 0.26 (SS/no tails fitting) to 1.77, 3.71 and 0.24 (SS/no tails fitting+SFA).

Conclusion: SFA-MLEM is a novel fully 3D approach that estimates scatter from the listmode directly and models out of field activity. Its performance is similar to that of SS/with tails fitting while requiring no data scaling.

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