Purpose: Dual-energy (DE) CT methods can separate two basis materials (e.g., soft tissue and bone) for applications such as dose calculations. However, typical DECT methods require either two scans or specialized scanners. We propose a statistical penalized weighted least-squares (PWLS) method to reconstruct two basis material images from a single-energy CT scan acquired with a simple split X-ray filter.

Methods: We used a pre-patient split-filter that contains 2mm aluminum across half the fan beam and 200 microns molybdenum for the other half. Using a 360-degree rotation of the X-ray source, the whole scanned object is exposed to two incident spectra with different effective energies during a single scan. We propose an optimization transfer method with a separable quadratic surrogate to monotonically decease a PWLS cost function with edge-preserving regularization. We first reconstructed the bone-corrected FBP images using the Joseph and Spital method, and separated the soft and bone components by a threshold to initialize the iterative algorithm. We used the ordered subsets approach to accelerate the convergence to a good local minimum.

Results: The test object is a chest NCAT image with 1.0 for soft tissue, 0.5 for lungs, 1.5 for spine, and 2.0 for ribs (the units are physical density: g/cc.). The lungs and soft tissue had the “soft tissue" characteristics and the spine and ribs had the “bone" characteristics. The root-mean-square (RMS) errors of the soft tissue, bone and density map were 0.03, 0.02 and 0.01 for PWLS, compared to 0.06, 0.03 and 0.05 for the FBP initialization for the noiseless simulation. The PWLS method removed the beam hardening artifacts more effectively than the FBP-JS method.

Conclusions: The proposed PWLS reconstruction method was able to separate soft tissue and bone images with low RMS errors from a single CT scan using a split-filter.

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