AbstractID: 13670 Title: Penalized weighted lease-Squares image reconstruction for low-dose CBCT: a comparison study of different edge-preserving penalties

Purpose: The penalty term plays an important role in determining the performance of statistics-based iterative reconstruction algorithms. In this work, we qualitatively evaluate the performance of a total variation (TV)-based penalized weighted lease-squares (PWLS) algorithm with two anisotropic quadratic (AQ) penalties in improving the image quality of low-dose cone-beam CT (CBCT).

Method and Materials: Low-dose CBCT projection data of a quality assurance CatPhan 600 phantom was acquired by a Varian Acuity simulator (Varian Medical Systems, Palo Alto, CA) using a protocol of 10mA/10ms per projection. CBCT images were reconstructed by minimizing an objective function based on the PWLS criterion with three penalty terms. The first one is the TV of the image. The other two are anisotropic penalties in quadratic form. The anisotropic quadratic penalty incorporates the gradient of image intensity of the reconstructed image by introducing an anisotropic coefficient for each neighbor of the quadratic penalty. In this work, two forms of anisotropic coefficient were investigated: one is in the inverse square form, and the other one is in the exponential form. In the anisotropic penalty, smoothness is discouraged between neighbors associated with a large gradient. We used a noise-resolution tradeoff measure to quantitatively evaluate the performance of PWLS with three penalty terms.

Results: Image improvement, in the terms of noise suppression and edge-preservation, is achieved by all of the three PWLS algorithms. At a noise-level comparable to a high-dose FDK reconstructed CBCT image, exponential-weighted anisotropic penalty shows the best spatial resolution of all the three. At a lower noise level, the TV-based term outperforms the AQ-based terms.

Conclusion: Noise in low-dose CBCT can be substantially suppressed by PWLS reconstruction algorithm and edges are well-preserved by both TV- and AQ-based penalty term. Different penalty terms should be used for better edge-preservation at different target noise levels.