ADVANCED LOW DOSE CT TECHNIQUES

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Purpose: The main risk factor in X-ray computed tomography (CT) is the radiation dose to the patient. This work develops image reconstruction methods for the following specific advanced low dose CT techniques: 1) noise reduction using low signal correction (LSC) 2) improved CT number accuracy, and 3) high pitch helical CT scanning. **Methods**: Analytical and model based iterative reconstruction (MBIR) methods were used in the above 3 techniques. 1) For LSC, raw count projection data was denoised using the adaptive trimmed mean (ATM) filter and the conventional filtered backprojection algorithm (FBP) was then used to reconstruct the image. Image noise and spatial resolution were assessed across the 2D ATM parameter space for low dose data compared to a high dose reference. 2) To improve CT number accuracy, the statistical weighting scheme in the reconstruction of a previously developed lesion-background model was modified to be the raw projection counts raised to an exponent, i.e. $\mathbf{N}^{\gamma}$. The statistical bias of the empirical weighting scheme was theoretically derived and experimentally measured. 3) To achieve helical reconstruction for pitches up to 4.0 for 16-, 32-, and 64-slice systems, first an extrapolation based FBP algorithm was implemented, followed by a deep learning network to remove data inconsistency artifacts, and finally a MBIR reconstruction was performed to further enforce data consistency. The method is referred to as DL-PICCS. RMSE and SSIM were used to assess final image quality. **Results**: 1) The ATM filter removes noise streaks and reduces noise magnitude, and the 2D parameter space can be assessed to select the tradeoff of decreased spatial resolution. 2) The CT number bias is inversely proportional to dose, and linearly proportional to contrast and the data weighting parameter γ. A theoretical value of $\gamma = 0.5$ was experimentally validated to yield zero bias. 3) DL-PICCS achieved quality images at pitch 4.0 for 16-slice systems and promising images for 32- and 64-slice systems. RMSE and SSIM improved at every reconstruction stage for all pitches and detector systems under study. **Conclusion**: These advanced CT reconstruction methods are able to effectively reduce radiation dose and the performance of each method has been presented.

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