Abstract: Self-supervised CT Dual Domain Denoising using Low-parameter Models

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Computed tomography (CT) is routinely used for three-dimensional non-invasive imaging. Numerous data-driven image denoising algorithms were proposed to restore image quality in low-dose acquisitions. However, considerably less research investigates methods already intervening in the raw detector data due to limited access to suitable projection data or correct reconstruction algorithms. In this work, we present an end-to-end trainable CT reconstruction pipeline that contains denoising operators in both the projection and the image domain and that are optimized simultaneously without requiring ground-truth high-dose CT data [1]. In addition to experiments with shallow convolutional neural networks, we use trainable bilateral filter layers as known denoising operators [2]. These custom filter layers only require gradient-based optimization of four parameters, each with well-defined effect on the filtering operation. Our experiments reveal that including an additional projection denoising operator in the CT reconstruction pipeline improved the overall denoising performance by 82.4–94.1 %/12.5–41.7 % (PSNR/SSIM) on abdomen CT and 1.5–2.9 %/0.4–0.5 % (PSNR/SSIM) on X-ray Microscopy data relative to the low-dose baseline. We have publicly released our helical CT reconstruction framework, Helix2Fan [3], which includes a raw projection rebinning step to render helical projection data suitable for differentiable fan-beam reconstruction operators and end-to-end learning. Additionally, the trainable bilateral filter layers employed in this study have been contributed to the medical open network for artificial intelligence (MONAI).

References

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