

Total variation and shearlets amalgamated regularization inverse models with automatic parameter selection

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In industrial X-ray computed tomography (XCT) imaging, we aim to uncover the interior 2D/3D structure of an object from a forward projection. Focusing on reconstruction problems with few-view data, we propose a novel model within proximal splitting algorithms that includes an automatic regularization parameter selection procedure.

Traditional reconstruction methods like FDK require a full-view scan, which takes a significantly long time to complete. To speed up the process, few-view XCT measurements with a limited number of projections have intrigued us. However, reconstruction from few-view data can be problematic when using these traditional methods. A critical challenge is achieving a balance between denoising and feature preservation, especially when dealing with the inherently sparse and noisy nature of few-view data.

In our robust reconstruction model, total variation and shearlet-based regularizers are combined to handle images with complex textures and edges. The regularization parameters can be space-variant, accounting for regions of the reconstructed image with different materials or noise levels. The automatic parameter selection procedure is achieved through a bi-level optimization problem, where fitness is measured against the ground truth. The proposed algorithm demonstrates advantages in few-view XCT imaging, effectively preserving edges for dimensional evaluation while reducing noise in the reconstructed images. Its effectiveness is further validated on a metal Ti-6Al-4V additively manufactured object, where it successfully reconstructs fine structural details while mitigating artifacts.