

Purpose:Four-dimensional Cone Beam Computer Tomography (4DCBCT) can provide respiratory phase resolved volumetric images in image guided radiation therapy. However, the undersampling of projections in each phase results in obvious streaking artifacts under the conventional FDK algorithm. In this work, we propose a novel iterative 4DCBCT reconstruction algorithm and an enhancement algorithm utilizing temporal nonlocal mean (TNLM) method.

Methods:For reconstruction, we introduce a TNLM term in the optimization model. Such a term favors those 4DCBCT images such that any anatomical features at one spatial point in one phase can be found in a nearby spatial point in neighboring phases. As for the image enhancement, 4DCBCT images obtained from the FDK algorithm are enhanced by minimizing the TNLM function while requiring that the solution is close to the FDK results. A forward-backward splitting algorithm and a Gauss-Jacobi iteration method are employed to solve the problems. The algorithms are implemented on GPU to achieve a high computational speed. Our algorithms have been tested on a digital NCAT phantom and a clinical patient case.

Results:Our reconstruction algorithm and the enhancement algorithm generate visually similar 4DCBCT images, but both better than FDK results. Quantitative evaluations indicate that, compared to the FDK reconstruction results, our reconstruction method improves contrast-to-noise-ratio (CNR) by a factor of 2.56~3.13 and our enhancement method increases CNR by 2.75~3.33 times. The enhancement method also removes over 80% of the streak artifacts from the FDK reconstruction results. The total computation time is ~460 sec and ~610 sec on an NVIDIA Tesla C1060 GPU card for the reconstruction and the enhancement algorithm, respectively.

Conclusions:Our new reconstruction and enhancement algorithms can effectively reduce the image artifacts in 4DCBCT. Comparing the two algorithms, the resulted image qualities are similar. The shorter computation time makes the enhancement algorithm more attractive.