

Purpose: On-board 4D cone-beam computed tomography (CBCT) is being actively pursued to help guide radiotherapy treatments of lung tumors. Among the existing 4D-CBCT methods, the McKinnon-Bates algorithm (MKB) has the advantage of being computationally efficient and not requiring additional scan time compared to a conventional 3-D acquisition taking on the order of 1 minute. The resulting images, however, can suffer from temporal hysteresis and ghosting artifacts that hinder tumor delineation and determination of motion trajectories. This work describes an improvement to the MKB algorithm that reduces or eliminates the ghosting artifacts and restores tumor conspicuity in the lungs.

Methods: Temporal blurring and ghosting are identified as being caused by motion-induced streaks in the 3D image that serves as the MKB prior and which, ideally, should be a time-averaged image of all respiratory phases. A prior destreaking method, using tissue thresholding and boundary erosion operations, is then proposed to remove the streaks without introducing new artifacts in the final phase images. The method is tested on simulated data using the XCAT phantom and on in vivo data from lung tumor patient. Image quality improvements are assessed in moving and static tissue.

Results: The prior destreaking technique successfully removed motion-induced streaks from the prior images, and the subsequent MKB reconstructions provided accurate spatial and temporal information. The lung tumor patient exhibited 6 mm of diaphragm motion that was not seen in the original MKB reconstruction, but was clearly recorded after prior destreaking was employed. Phantom images were similarly improved.

Conclusions: The MKB algorithm is enhanced by destreaking the prior image, and the proposed thresholding- and erosion-based technique is proven to be effective and efficient. This approach enables 4D-CBCT images to be acquired and reconstructed in a sufficiently short period of time for IGRT.

Funding Support, Disclosures, and Conflict of Interest:

All authors are employees of Varian Medical Systems.