AbstractID: 13329 Title: Real-time volumetric image reconstruction and 3D tumor localization based on a single x-ray projection image during lung cancer radiotherapy

Purpose: To develop an algorithm for real-time volumetric image reconstruction and 3D tumor localization based on a single x-ray projection image in a non-invasive, accurate, and efficient way for lung cancer radiotherapy.

Method and Materials: Given a 4DCT or 4DCBCT as the training data, we perform deformable image registration between a reference phase and all the other phases. The deformation vector fields (DVF) are parameterized efficiently by principal component analysis (PCA). Then we optimize the DVF applied to the reference image by adapting the PCA coefficients such that the DRR of the deformed image matches the acquired x-ray projection. The inherent regularization of PCA model allows us to reconstruct the volumetric image and localize the tumor in 3D space with a single projection. A realistic and dynamic mathematical phantom was used to validate the algorithm.

Results: We generated a dynamic phantom consisting of 60 phases with a 50% increase in breathing amplitude compared with training data. We simulated cone beam projections at all angles with spacing of 1° resulting in 360 projections. The average relative 3D image reconstruction error is 7.5% ± 2.4%. The average 3D tumor localization error is 0.9 mm ± 0.5 mm. We implemented our algorithm on an NVIDIA C1060 GPU. The computation time for each projection is achieved in less than 0.6 seconds (between 0.32 and 0.55 seconds depending on the extent of deformation).

Conclusion: We have shown the feasibility of reconstructing volumetric image and localizing tumor in 3D in near real-time using a single x-ray image. Further speedup may be achieved by better parameter initialization (e.g., using the previous frame in fluoroscopy) and GPU code optimization. Validation on patient data is under way. Clinical application can potentially lead to accurate 3D tumor tracking from a single imager.