

Purpose:For CyberKnife based SBRT, CT scan of a single breathing phase is utilized for real-time tumor tracking. However, x-ray images for tracking are more often not in phase with the reference CT. Non-rigid fiducial movement due to tumor deformation can induce significant uncertainties when matching images from different phases and this poses great difficulties for patient setup. A phase resolved fiducial setup scheme is developed that finds the best rigid transformation with tumor deformation corrected.

Methods:Five cases (2 liver and 3 lung patients) were retrospectively analyzed in this study. For each patient, two sets of fiducials (at the ends of exhale (EOE) and inhale (EOI)) were first aligned by their centroids and linearly interpolated to generate fiducial sets for the phases in between. The fiducial set in 3D at each phase is iteratively registered to the fiducial set in x-ray image until minimal residual error (RE) or mean distance between the projected fiducials and fiducials in the x-ray image is reached. The phase with the smallest RE after registration of fiducial sets in 5 phases is determined as the phase of the x-ray image.

Results:For a liver case, 30 pairs of x-ray images were registered to all 5 phases. The RE for registration with different phases was a smooth function with a distinct minimum. Fiducial matching for all the x-ray images was also performed to the EOE phase. The REs resulted by our method were 4.2 ± 0.58 mm, versus 5.3 ± 1.48 mm with only EOE phase used for registration. The latter represented the RE currently achievable in current system. Similar results were also observed for the other 4 patients.

Conclusions:In this study, a phase resolved fiducial setup scheme was developed and tested for 5 patients. It facilitates patient setup and tracking accuracy with reduced REs.