

Purpose:CyberKnife based SBRT is capable of tracking a moving target in real-time assuming a rigid-body motion. However, Observed non-rigid fiducial movements due to respiratory tumor deformation can induce uncertainties in tracking. Handling fiducial mismatch by trial-and-error is time-consuming and incurring extra imaging dose. A novel method is developed to automatically detect non-rigid fiducial movements and to evaluate the confidence in individual fiducials for tumor tracking.

Methods:The respiratory phase was first identified for registration of x-ray images and numerous sets of DRRs in correct phase were generated for fiducial matching. In an iterative process one fiducial was evaluated at a time. The fiducial set excluding the one under evaluation was registered to derive the optimal rigid transformation. The transformation was then applied to calculate the matching error for the evaluated fiducial only. The fiducials with dominating contribution to a large non-rigid movement would be identified when the matching error under evaluation was greater than the residual error from the registration. Following evaluation of all fiducials a confidence factor was assigned to each fiducial to be weighted, or even eliminated, for tracking.

Results:Our method was validated using data of 5 CyberKnife cases. Multiple x-ray images up to 25 pairs were studied for each case. In a lung case a single fiducial had 14.6 mm and 3 mm matching errors in two views, while all other errors were less than 2 mm. There was evident that the large fiducial error was due non-rigid respiratory motion. For other cases more stable matching errors less than 2.3 mm were obtained and confidence factors were evaluated.

Conclusions:An automatic detection of non-rigid fiducial motion will reduce fiducial tracking errors and thus treatment interruptions. Differentiating confidence level in individual fiducial will help to achieve accurate setup and tumor tracking for CyberKnife based SBRT, as well as conventional radiotherapy.