

Purpose: A critical component missing in the radiotherapy process for lung cancer is real-time monitoring of lung tumors. The large planning margin that is typically required to account for tumor motion compromises sparing of critical structures and normal tissues. A novel markerless method has been developed to monitor lung tumor motion during treatment.

Methods: The method automatically identifies lung tumors directly on continuous MV treatment beam images. Prior information from planning CT and contours is used to generate three sets of DRRs for lung tumors, other moving organs, and static organs, respectively. Composite DRRs are produced by combining three sets of DRRs, with weighting factors assigned to compensate for different attenuation coefficients between MV and kV x-ray energies. Individual locations of three set of DRR are optimized by comparing with acquired MV treatment beam images using a normalized cross correlation algorithm. The method was evaluated by monitoring a target moving inside a chest cavity phantom. It was also applied retrospectively to online MV images from lung cancer patients.

Results: In phantom studies, the target and target motion characteristics were successfully located within seven different treatment fields; the detected target locations have a maximum deviation of 0.8 mm from expected locations. Lung tumors in lung patients were successfully tracked. Although the planning 4D CT indicated that the lung tumor motion range was within 10 mm, real-time tracking suggested that: a) the lung tumor motion pattern is not regular; and b) the average tumor locations, the respiratory frequencies, and the tumor motion amplitude (range) vary considerably during treatment.

Conclusions: This tracking method, which requires no implanted markers and can be performed with no additional imaging dose, will enable clinicians to reduce margins and safely deliver higher doses by accounting for the effects of displacement and motion during treatment.