AbstractID: 5786 Title: Determination and validation of a 4D trajectory for respiration-induced real-time tumor motion tracking

Purpose: To model the tumor trajectory non-invasively by modeling the instantaneous tumor position using the “average” tumor position derived from a 4D CT scan. A real-time motion-synchronized idealized moving treatment couch was used to validate the trajectory dosimetrically.

Methods and Materials: In this study, we consider data from 7 patients who underwent a 4D CT scan – 5 lung tumors and 2 pancreas tumors. The CT images were retrospectively sorted according to phase, and the tumor contoured by a physician. The tumor’s trajectory was modeled parametrically, using a 5-term Fourier series to fit individual coordinate trajectories. These were then combined to yield a continuous 3D tumor trajectory. Compensation of this trajectory was modeled using a moving treatment couch with idealized dynamics. To validate the compensation, both a 7-beam conformal plan, and a 7-beam IMRT plan were ran for both the original and compensated tumor volumes for each patient.

Results: The RMS residual error for the fitted trajectories averaged 0.41 ± 0.22 mm, with a corresponding average tumor motion amplitude of 9.7 ± 5.3 mm. For patients with motion amplitudes greater than 5 mm, the average improvement in the 100% dose coverage between end-inhale and end-exhale was 24.3% for the 3D conformal plan, and 31.1% for the IMRT plan. Tumors with motion amplitudes less than 4 mm saw improvements in the 100% dose coverage of less than 1% for 3D conformal plans, and 8.2% for IMRT plans.

Conclusion: High-resolution tumor trajectories can be established with a 4D CT scan, and the tumor position can be sampled at a rate comparable to fluoroscopy tracking of implanted markers. Tracking and compensation using this technique has been shown to greatly improve the dose coverage and conformality for both 3D conformal and IMRT plans in comparison.