AbstractID: 5039 Title: Motion Encoded Beamlets for Optimization and Evaluation in Four-Dimensional (4D) Radiotherapy

Purpose To develop a simple model that fully utilizes the information of 4DCT and accurately incorporates *a priori* knowledge of patient motion into plan optimization and evaluation in 4D radiotherapy.

Methods and Materials We model the IMRT optimization as two independent schemes, the beamlet dose calculation scheme and the beamlet weights updating scheme. All motion information is encoded in the beamlet dose calculation scheme. A 4DCT is used to calculate beamlet dose associated with each phase. Deformable registration determines the voxel-to-voxel map from the arbitrary phase to the reference phase, which is used to map beamlet dose of the arbitrary phase to the reference phase. A priori knowledge of respiration is modeled as (time-dependant) probability density function of respiration phases. The motion encoded beamlet (MEB) is the probability-weighted summation of the deformed beamlet of the arbitrary phase. Dose calculation and plan evaluation is always in the reference phase. Beamlet weights updating scheme is same as static optimization.

We studied different optimization and delivery schemes in 4D radiotherapy. These studies include static optimization with various margins, free breathing delivery (FBD), gating deliveries (GD) with uncertainty and breathing synchronized delivery (BSD) with uncertainty.

Results As for the FBD considered, optimization using MEB show superior DVHs with reduced OAR dose than the margin-based optimization. GD is better than the FBD if proper gating phase is chosen and gating uncertainty is low. BSD is superior to FBD if synchronization is enforced during delivery. On the other hand, FBD shows greater tolerance to delivery uncertainty than GD and BSD method.

Conclusions Motion encoding through probability-weighted summation of beamlets is a flexible and powerful technique to incorporate arbitrary patient motion into optimization and evaluation. Through MEB, evaluations of different delivery schemes in 4D radiotherapy can be done in the same framework.