AbstractID: 5592 Title: A new 4D IMRT algorithm and its performance analysis

Purpose:

Current radiation treatment practice neither detects nor adapts to intrafraction organ motion beyond gating. We develop a simple optimization scheme for 4D IMRT which doesn't rely on gating and simulate its performance in the presence of the anticipated organ motion and unanticipated setup errors and tissue motion.

Method and Materials:

We wrote MATLAB code modeling treatment of a 2D phantom using the beamlet model. We also used geometry from a lung case. SNOPT (a commercial SQP optimization code) selects beamlet weights minimizing the weighted quadratic deviation from some desired dose.

Suppose the beam-on time is divided into N phases and the prescription dose is D^*. For location r in phase i, let $D_i^*(r)$ be the planned dose; $D_i(r)$ the actually delivered dose; and $r=A_i(v)$ the anticipated location of voxel v. Our two baseline algorithms use static plans ($D_i^*=D_j^*$ for any phases i,j) and gating ($D_i^*=0$ for phases $i\neq 1$). In both cases we choose feasible $D_1^*+...+D_N^*$ minimizing the weighted quadratic deviation from D^*. Our 4D algorithm selects

$$(D_1^*,...,D_N^*)\in \arg\min_{(D1\in F,...,DN\in F)} \sum_v \alpha(v)(D1(A_1(v)) +...+DN(A_N(v)) - D^*(v))^2$$

Simulation determines the delivered dose D_i from the anticipated dose D_i^* by adding noise and incorporating setup error (translation and rotation of the patient) and tissue distortion caused by unanticipated small organ motion. For our algorithm and the baseline, we compare the DVH of the cumulative dose $D_1+...+D_N$ and the margin needed to achieve a satisfactory cumulative delivered dose.

Results: We achieved significant improvement in the objective function (delivering more dose to the tumor and less to the organ) on our test case with 3cm motions.

Conclusion: This new paradigm of 4D IMRT holds significant promise for improving the current radiation therapy.