AbstractID: 9285 Title: Incorporating Uncertainty in Radiation Therapy Optimization with Scenario and Voxel Sampling

Purpose:

The inclusion of motion and uncertainty in treatment plan optimization requires the use of a potentially large number of geometric instances (scenarios), which may be computationally intractable.

We seek to provide a fast, flexible approach that is practical to implement.

Method and Materials:

When using a gradient-based optimization method, we have found that not every voxel and scenario needs to be computed at every step to converge to a near-optimal solution.

We first create a model of the dose actually delivered to the patient for a given set of beamlet intensities and geometric scenario. Based on this dose, we calculate the value of an objective function, a measure of how far a dose is from satisfying our clinical goals. We typically minimize the expected value of this objective function.

On each step of the optimization, we use several scenario samples to estimate the expected objective. To further speed up the estimate, we only calculate the dose to a fraction of the voxels within the patient per scenario. We use this sampling to estimate the gradient, which we use in a gradient-based optimization algorithm. At each step of the algorithm we use sample new scenarios and voxels.

We automatically tune the sampling rate for various structures by choosing the number of scenarios and voxels samples per step that minimizes the variance in the estimated objective.

Results:

So far we have tested the algorithm on 5 cases with a variety of treatment sites and several different motion models for IMRT and IMPT. Based on these cases, we find that voxel sampling combined with scenario sampling is over an order of magnitude faster than scenario sampling alone. This acceleration is achieved without sacrificing plan quality.

Conclusion:

The new approach is a fast, flexible way of incorporating uncertainty into the optimization.