AbstractID: 7283 Title: Accelerating IMRT Optimization by Voxel Sampling

Purpose: To develop a new algorithm to accelerate IMRT optimization by voxel sampling.

Methods and Materials: We note that standard gradient descent is fairly slow due to the time spent calculating the dose to the patient. We realized that a reasonable estimate of the objective function and gradient could be obtained by calculating the dose to only a fraction of the voxels in the patient. To avoid adding a systematic error, we randomly sample the voxels at each step to create an unbiased estimate of the gradient. Supposing sufficient samples are chosen, the errors in the gradient will tend to cancel each other out as the algorithm progresses.

Uniform sampling is inefficient, however, since small, important organs tend to need a higher sampling rate while large, less critical organs could use a lower rate. We developed an algorithm to tune the sampling rates for each objective by minimizing the variance of the estimate of the objective for a fixed overall sampling rate.

With the errors in the estimated gradient, we could not use techniques like conjugate gradient to further accelerate performance. However, we found that the delta-bar-delta algorithm provided an additional speed boost.

Results: For our example case of a lung patient with 384,979 voxels and 1460 beamlets we were able to achieve a speed improvement of approximately three times using uniform sampling, 14 times using automatically tuned sampling, and 20 times using delta-bar-delta with automatically tuned sampling. While the algorithms are randomized, the results were very reliable and stable in our experience.

Conclusions: Voxel sampling proves to be a viable way to dramatically improve the speed of IMRT optimization. It could be particularly helpful for applications such as temporo-spatial optimization and multi-criteria optimization, where a great many variants of a problem are optimized.