Dose Measurement-based Tomographic Intensity Modulated Radiation Therapy: Theory and Numerical Results

After a review of the theory of tomographic IMRT with a convolutional dose model, a tomographic IMRT algorithm incorporating phantom dose measurements is presented. Tomographic projection is replaced with a compensated summation using % depth-dose measurements, and backprojection is replaced with dose computed by interpolation from fixed field dose profile measurements. In this way, dose penumbra and fluence attenuation (% depth dose) effects are incorporated into tomographic IMRT inversion using special-purpose projection, backprojection, and beam front filtering. It is shown that penumbra deconvolution and geometric beam front filters often require unrealistic high spatial frequencies in beam front modulation. Penumbra effects and low spatial frequency modulation result in a reduction of the tumor dose edge or increased dose heterogeneity. Also, fewer beams are required to achieve optimum results under the constraint of low spatial frequencies in the dose and beam fronts.

The measurement-based inversion algorithm is coupled with a realistic beam front leaf-setting algorithm to demonstrate the trade-offs in tomographic IMRT resulting from dose effects. Comparisons between tomographic IMRT with and without the incorporation of real dose measurements are shown for a series of numerical targets to demonstrate these effects. Techniques are suggested for the removal of dose heterogeneity and normal tissue exposure by augmentation of the dose-based tomographic IMRT algorithm with dose constraints.