Adjoint Methods for External Beam Inverse Treatment Planning

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Forward and adjoint radiation transport methods may both be used to determine the dosimetric relationship between source parameters and voxel elements of a phantom. Forward methods consider one specific tuple of source parameters and calculate the response in all voxels of interest. This response is often cast as the dose delivered per unit source-weight.

Adjoint transport methods, conversely, consider one particular voxel and calculate the response of that voxel in relation to all possible source parameters. In this regard, adjoint methods provide an "adjoint function" in addition to a dose value. Although the dose is for a single voxel only, the adjoint function illustrates the source parameters, (e.g. beam positions and directions) that are most important to delivering the dose to that voxel. In this regard, adjoint methods of analysis lend themselves in a natural way to optimization problems and perturbation studies.

This work investigates the utility of adjoint analytic methods for treatment planning and for Monte Carlo dose calculations. Various methods for implementing this approach are discussed, along with their strengths and weaknesses. The complementary nature of adjoint and forward techniques is illustrated and exploited. Also, several features of the Monte Carlo codes MCNP and MCNPX are reviewed for treatment planning applications.