Post-Treatment Dose Reconstruction for Conformal Radiation Therapy and Tomotherapy Using the Convolution/Superposition Method

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Post-treatment dose reconstruction is the process of reconstructing delivered dose distributions inside the patient from an exit dose image obtained during the radiotherapy treatment. Portal imaging provides a method of determining the exit dose of the treatment from a megavoltage therapeutic beam. Utilizing the convolution/superposition method, this exit dose enables the reconstruction of the dose distribution from external beam radiation, provided an accurate 3D representation of the patient is known at the time of treatment.

The key to dose reconstruction is determining the primary energy fluence at the portal imager. The convolution/superposition method with an extended phantom accurately computes the dose at the plane of the portal image. The detected image at this plane represents the exit dose with the proper calibrations and conversions pertaining t o each measurement device. The ratios of calculated primary dose, scatter dose, or primary energy fluence to total dose can be used to extract their associated contributions from the measured portal dose image given the true geometrical orientation of the patient and beam.

An iterative method is used to determine the primary energy fluence exiting the patient. It is then back-projected through the patient to compute the TERMA (Total Energy Released per unit MAss) throughout the computation volume. The TERMA volume is then convolved with dose deposition kernels to reproduce the dose distribution in the patient. This method converges to the solution of the dose distribution given a known patient representation and orientation, dose deposition kernel and fluence attenuation lookup table. Furthermore, other than the beam spectrum, this technique assumes no prior knowledge of the incident fluence and includes the effects of scatter intrinsically in the model and thereby it more accurately represents the dose actually delivered.

This process of dose reconstruction can be utilized for dynamic wedges, multi-leaf collimators, intensity modulated beams , multiple beams, and a continuously rotating tomotherapy beam. The concept of dose verification becomes more important as the delivery of dose during treatment becomes more complex. Complex treatment fields from tomotherapy and multi-leaf collimation can induce more mechanical uncertainty and more scatter in the true incident fluence. The importance of dose verification is known and inherent in the design of the tomotherapy system.