

# **A model for the physical optimization of external beam radiotherapy**

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A model for optimizing conformal radiotherapy dose distributions is investigated. The algorithm is Newton's method of multidimensional function minimization. The objective was to perform a least-square fit of the dose distribution to the dose prescription.

An analogy is made between rotational radiotherapy and single photon emission computed tomography (SPECT) image reconstruction leading to: (1) an efficient approximate dose calculation that is a generalization of filtered backprojection image reconstruction, and (2) an efficient method of inverting a dose distribution into beam profile estimates that is similar to inverse filtered backprojection. The dose calculation is used in the algorithm to reduce the calculation time per iteration by roughly a factor of 20 for a 2D rotational problem. Likewise, the inversion method is used in the algorithm to reduce the total number of iterations to reach a solution by providing high-fidelity beam profile estimates corresponding to a residual dose distribution. Both models assume a non-divergent geometry and homogeneous medium. An adaptive bandlimiting filter is used in the inversion process to allow optimization of the gross structure of the dose distribution (corresponding to low spatial frequencies) during initial iterations, and the fine structure (corresponding to high spatial frequencies) at later iterations. Optimized beam profiles can be significantly corrupted by computational 'noise' artifacts introduced in the calculation of the dose residual. A simple method of noise suppression is incorporated into the algorithm resulting in smoother beam profiles that are easier to achieve clinically. Good agreement was achieved between calculation and measurement for two test cases.

The optimization model predicts that a large number of modulated beam profiles are required to maximize conformation of the dose distribution to the dose prescription. Currently this is not practical with existing technology. A new method of treatment realization similar to spiral CT scanning called Tomotherapy is described. The tomotherapy unit would incorporate a diagnostic CT scanner for acquiring tomographic images prior to and during a treatment for optimized treatment planning and treatment verification, respectively. Tomotherapy represents the first truly integrated approach to optimized treatment planning, delivery and verification of external beam radiotherapy and could significantly advance the state-of-the-art in radiotherapy.