A framework for the optimization of intensity modulated radiotherapy

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In recent years, the development of intensity modulated radiation therapy (IMRT) has provided many new opportunities in the delivery of conformal radiotherapy. These new opportunities, however, are accompanied by a number of difficult challenges. One key challenge is that of developing a suitable approach to optimizing each patient's treatment plan.

A test environment using pencil beam data sets has been developed that provides an efficient means of investigating some of the unresolved issues in IMRT. For example, a study was performed that examined the extent to which a treatment plan can be improved through either an increase in the number of beam angles and/or a decrease in the collimator size. The pencil beam data sets have also been used to investigate a number of mathematical programming approaches to optimizing treatment plans for IMRT. Linear, nonlinear, and mixed integer programming approaches have been examined, and two implementations of dose volume constraints have been tested. Three iterative approaches to optimizing treatment plans have also been explored; the Ratio Method, Iterative Least Squares minimization, and the Maximum Likelihood Estimator. A series of clinical tomotherapy treatment plans have been developed using both the mathematical programming techniques and the iterative approaches to dose optimization. These results have been used to analyze the performance of each technique in the optimization of very large treatment plans.

The results demonstrate that nonlinear programming approaches provide the flexibility to develop an acceptable treatment plan for almost any disease site. With nonlinear programming techniques, it is possible to include dose volume constraints in an optimization model. With the addition of penalty functions, the iterative approaches to dose optimization offer a flexible and robust approach to determining each patient's treatment plan. A primary strength of the iterative optimization techniques is their ability to perform efficiently in conjunction with a convolution/superposition based dose computation. These techniques can optimize large-scale treatment plans while minimizing both memory demands and time requirements.