

AbstractID: 1474 Title: An exact approach to aperture modulation in IMRT treatment planning

We present an exact approach to the IMRT fluence map optimization (FMO) problem using aperture modulation, where we directly optimize the intensities of deliverable apertures. Our approach provides a solution to the dilemma that restricting consideration to a predefined limited set of apertures or local update rules for improving apertures cannot guarantee that the best treatment plan is found, while the total number of deliverable apertures is too large to take into account explicitly. We employ a technique called column generation that starts by optimizing the intensities of a conformal plan and then iteratively adds deliverable apertures while the quality of the treatment plan can be improved. At each step, the most promising new apertures are found by solving a subproblem called the pricing problem. This problem employs the slopes of the objective function with respect to the individual beamlet intensities to form new apertures from the entire set of deliverable apertures. Our approach is guaranteed to converge to the unconstrained beamlet-based FMO solution, which allows us to measure the quality of the aperture-based solution in each step and thereby assess the trade-off between delivery efficiency and plan quality. We present efficient algorithms for solving variants of the pricing problem that can account for interdigitation or connectedness constraints when these are imposed by the multi-leaf collimator (MLC) system, and that all account for the row-convexity constraints present in all MLC systems. The effectiveness of our approach using a constrained least-squares formulation of the problem is demonstrated on clinical data.