

Purpose: Direct aperture optimization (DAO) has the potential to simplify and therefore accelerate IMRT delivery. However, the algorithmic side of DAO is challenging. The commonly used simulated annealing algorithm is slow. Moreover, it is not guaranteed to find the best solution. This motivated us to investigate the feasibility and utility of mixed integer programming (MIP) in DAO."

Method and Materials: We consider an objective function which is linear in dose. For the dose calculation, we apply a dose matrix concept. The dose D_q in a voxel q is given by $D_q = \sum_n \sum_j w_{nj} d_q^{nj}$, where w_{nj} is the fluence weight for beamlet j in aperture n and d_q^{nj} is the precalculated dose contribution of this beamlet to voxel q for unit fluence. In order to form valid apertures, two types of conditions have to be imposed on the beamlet weights. First, beamlet weights w_{nj} which belong to the same aperture have to be either zero or equal to a common aperture weight. Second, non-zero beamlet weights which belong to the same leaf pair must be connected, i.e. if two beamlet weights in one row are non-zero, the weights in between have to be non-zero as well. Both conditions can be formulated in terms of linear constraints if a binary variable for each beamlet is introduced.

Results: The formulation has been tested for the RTOG benchmark phantom which mimics a paraspinal case using the commercial software CPLEX. The mixed integer program could not be solved to optimality, however, integer solutions were obtained within a reasonable computation time.

Conclusion: The mixed integer formulation for DAO was applied successfully to an idealized phantom geometry. Current research considers the applicability to large size clinical cases.