AbstractID: 7591 Title: IMRT Inverse Planning with Voxel-Based Penalty Scheme

Purpose: A tacit assumption made in current inverse planning algorithms is that all points within a structure (target or sensitive organ) are equivalent, as reflected by the fact that the dose prescription, weighting factors and dose-volume constraints are generally imposed *a priori* on a structure-specific basis. This seriously limits the IMRT solution space and compromises the achievable dose distributions. The purpose of this study is to develop a novel IMRT inverse planning framework with a more general voxel-specific penalty.

Methods: Different from conventional inverse planning in which the same penalty (objective) function is used for all voxels, here we assign each voxel a penalty proportional to $[D_c(i) - D_0(i)]^{n_i}$, where D_c and D_0 are computed and prescribed doses, respectively, and n_i is a voxel-specific exponent. In this way, we "break" the implicit constraint that a structure is a mathematically uniform entity with all voxels having the same "identity". The seemingly insolvable task of determining a large number of voxel-specific $\{ n_i \}$ is dealt by heuristically relating them to the doses they receive. The optimization starts from a uniform value of $n_i = 2$ and, during the iterative optimization process, the n_i's are treated as parts of the system variables and are updated together with the beamlet weights. If a voxel is overdosed, for example, it means that the voxel is not penalized sufficiently and the algorithm will automatically increase the value of n_i, and *vice versa*.

Results: A voxel-dependent penalty scheme is established for IMRT inverse planning. The formalism properly models the intra-organ tradeoff and allows the optimizer to access solutions that would otherwise be inaccessible. Our phantom and clinical head-and-neck case studies show that much superior treatment plans can be obtained as compared with the conventional approaches.

Conclusion: Voxel-based penalty scheme leads to substantially improved IMRT dose distributions and allows us to maximally utilize the IMRT technology.