AbstractID: 3306 Title: Robust optimization including effects of systematic treatment errors

Purpose: Intensity-modulated treatment planning methods have not previously accounted for systematic errors in tumor and tissue locations. We introduce a novel method for including systematic errors during the optimization phase, based on estimated probabilities of systematic geometrical shifts or tissue misidentification(i.e.tumor location).

Method-and-Materials: Given a planning geometry, the users supply estimates of the systematic probability that tissues are actually displaced by a given vector("ensemble"). Overall plan quality is based on probability-weighted measures of actual plan realization. Ensembles are estimated here based on dose-convolution with Gaussian probability distributions. Two different objective function metrics based on this paradigm are investigated:the maximum probability of tumor under-dosage is computed using integer variables which divide dose values into under-dose vs. adequate dose. Similarly, the probability that dose to a critical serial normal structure will exceed tolerance is formed into an objective function. A third metric is the uncertainty in the mean dose given to the tumor, averaged over ensembles. Both of these can be mixed with other standard metrics in the IMRT treatment planning optimization process.

Results: Mathematical formulas for the metrics were derived. We demonstrate the use of ensemble averaging using large-scale mixed integer programming. A systematic setup shift Gaussian probability distribution of 5 mm(half-width) was assumed. A lung treatment plan was tested partly based on minimizing the highest probability of clinical target volume under-dosage. The plan was more robust against systematic errors than the comparable plan without considering the robust metric.

Conclusion: Systematic uncertainties can be considered directly within the optimization process by averaging over ensembles. The result is increased robustness of the treatment plans. The method of estimating dose to the ensemble treatment plans needs to be studied to potentially improve its accuracy. We have introduced novel metric functions based on explicitly considering the effects of systematic errors, thereby resulting in treatment plans of increased robustness.