AbstractID: 5019 Title: Regularization and the L-curve for inverse planning based on equivalent uniform dose

Purpose: In the dose optimization based on equivalent uniform dose (EUD), a single dose value is assigned to PTV or organ at risk. Obviously, this optimization problem is poorly defined – there is an unlimited number of nonuniform dose distributions (and, correspondingly, beam intensity functions) which will satisfy the EUD-based objective function. Together with the ill-posedness of the underlying integral equation, this may present a challenging mathematical problem. We propose an objective function for the EUD-based inverse planning which can solve this problem and produce stable and accurate numerical solutions.
Method and Materials: We apply to EUD-based inverse treatment planning a variational regularization technique which was previously studied for the least squares dose optimization. The regularization parameter is found using the L-curve method which is based on minimization of the residual norm and the smoothing norm of beam intensity functions. The optimization technique is applied to the prostate cancer treatment.
Results: We have compared inverse treatment planning with the standard least squares objective function and an EUD-based objective function. The dose distributions obtained from EUD-based optimization are extremely nonuniform with significant hot spots in the PTV. We have applied to the EUD-based optimization the variational regularization technique with the L-curve method for determining an optimal value of the regularization parameter. We demonstrate that the regularization method decreases dose variance and mean dose in the PTV while keeping EUD of the same value. The regularized dose distribution is stable and uniform in the PTV.
Conclusion: Inclusion of a variational regularization technique into the EUD-based dose optimization produces robust dose distributions and beam intensity functions without deterioration of optimization accuracy.