Purpose:

Dose-volume histogram (DVH) is a clinically relevant criterion to evaluate a treatment plan quality. It is hence desirable to incorporate DVH constraints in treatment planning process for intensity modulated radiation therapy (IMRT). Yet, these constraints usually lead to difficulties due to their non-convex nature. The purpose of this project is to solve the IMRT optimization problem with DVH constraints using a hybrid-input-output (HIO) method.

Methods:

The IMRT optimization problem finds a dose distribution $z$ under two constraints, where the elements of the vector $z$ are the dose value at each spatial coordinate. First, there exist a corresponding fluence map $x$ such that $Dx=z$ and $x>0$, where $D$ is the dose deposition matrix. Second, the dose distribution $z$ should satisfy the DVH constraints. These two constraints define two sets of the dose distributions, denoted by $A$ and $B$, and the solution to the IMRT problem lies in the intersection of these two sets. Our method finds the solution via the HIO algorithm that iteratively updates the solution according to its projections onto the two sets until convergence. The projection to $A$ is handled by solving a least square problem and the projection to $B$ is achieved by gradually adjusting voxel doses that validate the DVH criteria to meet the constraints.

Results:

We have tested our algorithm using 7-field IMRT plans for 4 prostate cancer cases. Clinically relevant DVH constraints are considered for PTV, rectum, and bladder. In all the cases, the algorithm is able to find the solutions that satisfy all the DVH constraints.

Conclusions:

We have developed an algorithm to solve the IMRT optimization problem with DVH constraints using the HIO approach. Tests conducted in prostate cancer cases have demonstrated the effectiveness of our algorithm.