A Novel Method to Accelerate Optimization by Employing Approximate Dose Values

We have developed a method that utilizes pre-computed additive dose approximation (ADA) values in order to significantly reduce the required computation time for beam weight or fluence optimization. The concept of the ADA is demonstrated in Figure 1. The numerical sum of DVH values for two beams is approximately equal to the true DVH of the combined beams. Figure 2 indicates that the relationship between these numerical sum dose values and the true dose values are approximately linear for various beam weight combinations. Using a linear correction factor, obtained by randomly sampling the beam weight space, further improves the approximation. This produces a linear objective function (LOF), which is optimized to provide a favorable initial point for optimization of the standard objective function. Figure 3 compares our method with the standard optimization method. It can be seen that some overhead time is required to implement the ADA, namely the calculation of the correction factors and optimization of the LOF. However, since the manipulation of large matrices is avoided, this overhead is only 3-16 s, depending on the number of variables. The results of the evaluations are summarized in the table. The standard and ADA methods produced similar optimized weights. Note the significant decrease in CPU time and number of function evaluations with our method. This approach can be scaled up for any problem involving dose-volume objectives, including multi-criteria optimization.

<table>
<thead>
<tr>
<th>Number of Patients</th>
<th>Patient Type</th>
<th>Number of Variables (Beams or Beamlets)</th>
<th>ADA Func. Evaluations</th>
<th>Standard Func. Evaluations</th>
<th>ADA CPU Time (s)</th>
<th>Standard CPU Time (s)</th>
<th>% Time Saved</th>
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