AbstractID: 13273 Title: Non-Voxel-based-Broad-Beam (NVBB) framework for IMRT treatment planning –-II. Ultra-fast intermediate dose calculation

Purpose: IMRT treatment plan optimization requires a fast yet accurate algorithm to calculate intermediate dose in each iteration. Conventional finite size pencil beam (FSPB) approaches have limitations such as: limited resolution, significant pre-calculation time, huge memory demand, and limited accuracy in the presence of heterogeneity. In this work, we present a fast dose calculation algorithm that overcomes the limitations of FSPB approaches.

Material and Methods: By decomposing the infinitesimal beam dose kernel into the central axis (CAX) and lateral (LSF) components and taking the beam eye view (BEV), we established a Fluence-map-Convolution-Broad-Beam (FCBB) dose calculation formula. The Collapsed-cone convolution/superposition (CCCS) doses on water phantom with standard setups and various field sizes are used to derive LSF and CAX, the commissioning data for FCBB. The proposed dose calculation involves a 2D fluence map convolution with LSF followed by table-lookup with inverse square correction of CAX based on radiological distance calculated via ray-tracing the density volume. The complexity of FCBB is $\mathcal{O}(N^3)$ both spatially and temporally, which is orders of magnitude smaller than FSPB in spatial complexity and orders of magnitude faster than CCCS.

We implemented FCBB algorithm in C++ language and compared it with CCCS using both simulated and clinical cases. The clinical cases include prostate, H&N and lung patients that were optimized with TomoTherapy TPS.

Results: For all tested cases, simulated or clinical, the dose calculation time for CCCS varied from hundreds to thousands of seconds when run on a single PC. It was reduced to sub-seconds to seconds for FCBB on the same PC. As for the dose differences between FCBB and CCCS, about 90-95% of voxels have Gamma indexes less than 1 for the 3mm/3% criteria.

Conclusions: The FCBB algorithm has low memory demand, is ultra-fast and accurate enough for intermediate dose calculation during IMRT optimization.