AbstractID: 13218 Title: Non-Voxel-based-Broad-Beam (NVBB) framework for IMRT treatment planning –-III. Ultra-fast full dose calculation

Purpose:
Dose calculation is essential in treatment planning in radiation therapy. Collapsed Cone Convolution/superposition (CCCS) based dose calculation is regarded as clinical standard in terms of accuracy. It is essential to run a CCCS based dose calculation before accept the plan. Our main objective is to develop an ultrafast GPU-based CCCS dose calculation engine capable of performing near real-time dose calculation with a single PC.

Method and Materials:
The dose calculation engine in commercial TomoTherapy® system is re-implemented using NVIDIA's CUDA language. In order to fully unleash the power of GPU, algorithms are modified to better suit the GPU architecture. A non-voxel based ray-tracing algorithm is used for TERMA calculation to avoid write-conflicts and utilize GPU's free texture interpolation. An exponential dose kernel model is used for CCCS calculation that reduces the computation by over 100. Efforts are made to ensure the coalesced memory access throughout calculation.

Results:
The GPU dose engine running on a single NVIDIA GTX-295 card is compared with the original commercial version running on a CPU cluster for both performance and accuracy. Extensive tests were run that includes different delivery modes (TomoHelical^{SM}, TomoDirect^{SM}) and different disease sites on either patient CT or Tomo® cheese-phantom. The GPU algorithm on one GTX-295 is 8-16 times faster than original dose engine running on a 14-blade (consists of 28 dual-core Xeon5148 2.33GHz CPUs) TomoTherapy® high-performance cluster. This translates to a speedup of 200-400 over a single Xeon5148 CPU. The new GPU dose engine produces doses that are within 1%, 1 mm of original dose engine. It is also within 3% of the ion chamber and film measurement, passing all verification tests.

Conclusion:
We developed an ultrafast GPU-based CCCS dose engine. Compared with the current cluster based commercial product, performance gains and accuracy verification are demonstrated.