AbstractID: 13917 Title: GPU-Accelerated kV/MV Dose Computation

Purpose: To develop a comprehensive GPU-accelerated, superposition/convolution based dose calculation engine supporting both a modern dual-source MV model and an analytical kV source model

Method and Materials: An analytical kV source model was developed for use with the Small Animal Research Radiation Project (SARRP), which analytically calculated the fluence to every voxel. The MV source model contains a traditional primary and an enhanced extra-focal algorithm that efficiently accounts for leaf-height effects. The spectral and attenuation effects of static beam modifiers were integrated into each source's spectral function. The total energy released per unit mass (TERMA) computation used back-projection with optional exact multi-spectral attenuation. Superposition/convolution was implemented using the inverse cumulative-cumulative kernel and exact radiological path ray-tracing with optional kernel tilting. Two superposition variants were implemented and benchmarked. Multi-resolution superposition approximates true, solid angle ray-tracing. Arc superposition increases the relative temporal TERMA sampling.

Results: The kV source model performance was integrated into the TERMA computation, increasing performance in a volume resolution and collimator size dependent manner. MV source model performance was <9ms (data dependent) for a high resolution (400^2) field using an NVIDIA GeForce GTX 280. Our TERMA GPU implementation was improved, doubling performance. Our GPU Superposition implementation was improved by ~18% to 0.058 s and 1.186 s for 64^3 and 128^3 water phantoms; a speed-up of 80-142x over the highly optimized Pinnacle[3] (Philips-Madison, WI) implementation. Pinnacle[3] times were 8.3 s and 94 s, respectively, on an AMD Opteron 254 (2 cores, 2.8GHz). Extensive accuracy benchmarks indicated that Arc Superposition increases dose computation efficiency and that Multi-Resolution Superposition slightly under estimates MV intra-patient scatter.

Conclusions: We have completed a comprehensive, GPU-accelerated dose engine in order to provide a substantial performance gain over CPU based implementations.