AbstractID: 9386 Title: Towards in vivo Dose Validation Using Real-Time Physiologically Constrained Deformable Image Registration

Purpose: To develop an adaptive radiotherapy (ART) strategy based on in vivo dose verification using volumetric imaging, real-time physiologically constrained deformable image registration (PC-DIR) and high performance computation (HPC).

Method and Materials: Comparison of delivered and planned dose distributions for patients undergoing radiation therapy, especially IMRT, can be used to estimate treatment outcome, and develop a successful ART strategy that accounts for patient positioning errors, organ deformation, physiological changes (i.e. tumor shrinkage, edema), and incorporating this back into the treatment planning. Using 4DCT imaging, we have developed a ART methodology based on 1) PC-DIR for auto-contouring; 2) automated internal target volume generation; 3) probability density function (PDF) for specific structures; and 4) graphics processor unit (GPU) based HPC for real-time computation using NVIDIA 8800GTX.

Results: Compared with the same algorithm without the PC constraint, PC-DIR resulted in superior performance with up to 91% reduction in inverse consistency errors. The computer generated ITV yielded contours typically within 3mm of physician drawn contours, and also served as a check of physician drawn ITVs. The PDF was constructed for the ITV to determine the dose distribution based on spatial probability using time averaging over a respiratory cycle. GPU based registrations of 256x256x64 imaging volumes required 3.6 sec for 100 iterations, a 56X speedup compared with conventional CPU computing (i.e. dual core 2.4GHz CPU). Dose remapping and dose volume histogram computations were near real-time ($\leq$3sec).

Conclusion: We have developed key elements of a clinically implementable ART strategy, which include real-time computations using GPU, and accurate and robust registrations based on PC-DIR. These elements incorporate 4DCT imaging coupled with GPU based PC-DIR and frequent conebeam CT (CBCT) verification. This methodology can exploit ongoing improvement in GPU hardware performance and CBCT image quality.