Abstract ID: 16685 Title: A framework for 4D and adaptive planning workflow incorporating Monte Carlo-based optimization and dose calculation

Purpose: Development of tools for 4D and/or adaptive planning workflow in the clinical setting, incorporating advanced dose algorithms for inverse planning, has been evolving slowly. The purpose of this work was to develop a framework for 4D and/or adaptive treatment planning in the clinical setting, incorporating Monte Carlo-based dose calculation for optimization and dose calculation.

Methods: The framework incorporates several modules for 4D and/or adaptive planning, including, (a) planning and optimization on individual, respiratory-correlated CT datasets using a Monte-Carlo-based dose engine (EGSnrc/BEAMnrc for the head model and modified DOSXYZnrc for the patient calculation); (b) deformable image registration based on a finite element method (FEM); (c) dose accumulation involving mapping of energy and mass to the reference phase; (d) plan evaluation. For MC-based optimization, beamlet 3D doses are computed and the inverse problem is solved using quadratic objective functions. Beamlet intensities are optimized using a gradient-based search method. The framework was applied to a simulated lung phantom using FEM to simulate lung deformation. Beamlet-doses were substituted into the re-optimization objective function, minimized on the initial CT dataset. With the resultant beam configuration, the dose was calculated on the deformed image, and accumulated/mapped to the reference image to compute the “warped” dose. The treatment plan was then re-optimized.

Results: The MC-based optimization procedure was verified using square field depth doses and found to be within 2% of measurements. The optimization was also applied to a clinical lung patient plan and was found produced a significantly more homogeneous distribution than the conventional pencil-beam algorithm. For the example case, results indicate that the 90% iso-dose coverage to the PTV was 97%, 78% and 96% for the initially planned, delivered, and re-optimized doses, respectively.

Conclusion: Initial results suggest that the framework may help facilitate use of 4D and adaptive planning in the clinical setting.