AbstractID: 5819 Title: Unified algorithm for kV and MV scatter and beam-hardening correction using the convolution-superposition method

Purpose: Quantitative cone beam CT (CBCT) is essential for advanced radiation oncology (RO) applications such as portal image-based 3D dose reconstruction. Quantitative CT requires accurate modeling of scatter, beam-hardening and detector response. Scatter correction methods are typically semi-empirical in nature and are designed to reduce visible artifacts while incurring low computational cost. In contrast, Monte Carlo (MC) methods are accurate but impractically slow. Convolution-superposition (CS) scatter models offer a good balance between accuracy and computational complexity. We show how CS can be employed to implement a unified correction method that enables quantitative kV and MV imaging.

Method and materials: (1) We perform detailed MC modeling of the kV and MV cone beam imaging systems. (2) Using MC, we generate calibration data that map intensities recorded on the flat panel imagers to water-equivalent thicknesses (WETs). (3) The MC models are used to generate pencil beam kernels for water cylinders of varying thickness. (4) Scattergrams are generated from acquired projection images via the CS method using these kernels indexed by the WET at each pixel. (5) Scattergrams are iteratively refined using a multiplicative correction formula that ensures that the estimated primary image remains non-negative even when scatter-to-primary ratios are very high. (6) The FDK reconstruction algorithm is applied directly to the thickness maps corresponding to the estimated primary images.

Results: The algorithm is able to reduce maximum non-uniformity in the reconstruction of a 16cm cylindrical homogeneous tissue equivalent phantom from 11.7% to 1.5%. When applied to a challenging 35cm x 22.5cm oblong water phantom, a non-uniformity reduction in from 36% to 2.5% is achieved. A dataset of 200 1024x1024 projections can be processed in 25 seconds. Conclusions: CS methods can be used at both kV and MV energies to enable reconstruction of quantitative CBCT images.

Conflict of interest: Supported by Siemens.