AbstractID: 5276 Title: Using Convolution Superposition to Guide Denoising of Monte-Carlo Dose Distributions

Purpose: Monte Carlo (MC) dose calculations can be accurate but are time consuming as well. In contrast, convolution superposition (CS) offers a fast and smooth result but is potentially less accurate. In this work, we attempt to take advantage of the convolution superposition result and noise filtering methods to guide and accelerate Monte Carlo calculations.

Method and Materials: We investigated two methods to utilize convolution-super position in Monte-Carlo denoising. In the first method, the residual difference between MC and the overall result is denoised using multi-scale (wavelet and contourlet) methods and iteratively added to the overall result. The iterations are initialized by the CS result. In the second method, low-frequency components are determined using Mont Carlo calculations whereas high frequency components are determined using CS results. 3-D Butterworth filters are used to make the split. The methods were evaluated using a lung and head and neck case. The MC dose distributions were calculated by the open-domain Dose Planning Method MC code with varying number of histories (125000, 250000, and 500000) and corresponding uncertainties of 6%, 4%, and 3%, respectively.

Results: We observed that both the residual-based contourlet method and frequency splitting by Butterworth filters provided better performance than using wavelet-based residuals. Frequency splitting is much faster (a few seconds) compared to contourlet computations (10-15 min in the current prototype implementation).

Conclusion: This is the first demonstration of the (hybrid) use of fast dose computations to guide and accelerate Monte Carlo calculations. We demonstrated two promising techniques. Of the two, the contourlet method retains more of the high-frequency results from the Monte Carlo simulations, whereas the Butterworth frequency-splitting method is much faster. The results are promising for future investigations.

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