IMPROVEMENT OF LDR BRACHYTHERAPY TG-43 DOSE CALCULATION WITH A GPU-ACCELERATED RAYTRACEING ALGORITHM

Alexandre Bourque\textsuperscript{1,2}, Jean-Philippe Gariépy\textsuperscript{3}, Dominique Mathieu\textsuperscript{3}, Sami Hissoiny\textsuperscript{4}, Luc Beaulieu\textsuperscript{1,2} and Philippe Després\textsuperscript{1,2}

\textsuperscript{1}Département de radio-oncologie et Centre de recherche en cancérologie, Hôtel-Dieu de Québec, 11 Côte du Palais, Québec, QC, Canada, G1R 2J6.

\textsuperscript{2}Département de physique, génie physique et optique, Université Laval, Québec, QC, Canada, G1K 7P4.

\textsuperscript{3}Département de radio-oncologie, Centre hospitalier de l’Université de Montréal, 1560 rue Sherbrooke Est, Montréal, QC, Canada, H2L 4M1.

\textsuperscript{4}Département de génie informatique et génie logiciel, École Polytechnique de Montréal 2500 Chemin de Polytechnique, Montréal, QC, Canada, H3T 1J4.

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\textbf{Purpose}

To compare a fast GPU-based dose calculation algorithm to Monte Carlo (MC) simulations and TG-43 results in low dose rate brachytherapy, in terms of accuracy and relative execution speed.

\textbf{Method and Materials}

Dose calculations were performed in a voxelized numerical phantom comprising bone, air and gold inserts. The source consisted in a single seed of \textsuperscript{125}I (SelectSeed, Nucletron, The Netherlands). Dose distributions were obtained from calculations based on the TG-43 formalism, from MC simulations (GEANT4 v.9.3) and from a GPU-based version of the TG-43 formalism capable of handling heterogeneities. This feature was implemented in the GPU algorithm by computing the equivalent water length travelled through each voxel between the emission site and the dose calculation point.

\textbf{Results}

Dose profiles were plotted along heterogeneities to visualize the behavior of each method, with MC simulation as the gold standard. Unsurprisingly, the TG-43 method overestimated the dose behind high-density/high-Z regions with errors in excess of 100\% in some case. The modified TG-43 algorithm implemented on the GPU algorithm was able to better reproduce MC results, with errors in the range -9.3\% to 10.5\% behind the same regions. Larger differences occurred for backscattering effects, which are only modeled in the MC method, but only on a limited region (1-2 mm). The TG-43 formalism provides dose distributions almost instantaneously while MC simulations typically required up to four hours for statistically significant results. The modified TG-43 GPU algorithm was able to reproduce MC results in approximately four seconds.

\textbf{Conclusions}

For complex geometries, the GPU-based TG-43 algorithm was shown to provide dose distributions that are closer to those obtained with MC simulations while being significantly faster. This improvement can potentially improve the planning in LDR brachytherapy, where inter-source attenuation and tissue heterogeneities were shown to influence dosimetric parameters.
Dose profile along X axis in numerical phantom

- TG-43-RT
- Monte Carlo
- TG-43

Distance from source [mm]

Absolute dose [Gy]