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Accelerated simulations for in-silico radiological medicine: what is needed?

Background: In-silico replication of radiological examinations in medicine opens the possibility of development and accelerated acceptance of new apparatuses in the clinical practice reducing time, costs and exposure risks for volunteers. However, the computation of realistic radiological images rises the need of huge computational capabilities, with a single examination needing up to 1014 simulated events. We aim at exploring the use of GPU based Monte Carlo architectures for making such in-silico study time-sustainable.
Materials and methods: We compared two GPU based Monte Carlo toolkits (GGEMS and MC-GPU) and a Geant4 based monte carlo software, used as ground truth. The work was meant to compare physics (generated images and dose) and computation times in several tests willing to replicate radiographic procedures. GPU based simulations were run on GPU NVIDIA V100 while CPU based simulations were run on 2x AMD EPYC 7281 16-Core Processor.
Results and conclusions: No statistically significant differences arose between the comparison of the simulated physics. Hence, the signal spectrum, the scatter profiles as well as the image quality resulted the same between simulations performed with the three toolkits. Similarly, no differences were observed between the simulated patient doses. The use of the GPU based platform permitted a conspicuous improvement of the computation times, up to 3 order of magnitude. However, the GGEMS simulations did not permitted to simulate an x-ray beam coherent with edges of rectangular detector, but just with circular footprint. This implied the use of simulated collimators that increased the computation time. On the other hand, the Geant4 toolkit permitted more flexibility in the simulations, with larger possibilities to customize parameters and output. Moreover, the voxellized geometry in the GPU based simulations presented some artifacts in the simulated images, mainly due by the resolution of the input voxel size that should be taken into account.
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