Purpose: The rapid evolution of x-ray Computed Tomography (CT) technology has led to tremendous benefits, as well as a serious concern about the excessive radiation doses. To quantify the patient-specific risk from CT scans, fast and accurate dose calculation is a prerequisite. The goal of this work is to develop a GPU-based Monte Carlo (MC) dose calculation package, gCTD, to assess radiation dose received by a patient in CT/CBCT scans.
Methods: We have developed the MC dose calculation code on GPU architecture under CUDA platform. Photon cross section data of various interaction types in kV energy range are obtained from PENELOPE database. Woodcock transport technique is used for simulating photon transport without voxel boundary crossing. Electrons are not explicitly simulated, due to their small range (less than voxel size) in the kV energy region. During the simulation, a large number of GPU threads are launched and each of them is simulating one photon transport. High performance random number generator and hardware linear interpolation of cross section data are utilized. Source energy spectrum and fluence map after a bowtie filter are also modeled. The developed gCTD package is tested using an NCAT digital phantom and a realistic head-and-neck cancer patient under a CBCT scan.
Results: With one billion source photons simulated, the average relative uncertainty is 0.47~0.67% in high dose region where the dose is above 30% of the maximum dose. High computation efficiency has been achieved on an NVIDIA Tesla C2050 GPU card, such that the computation can be finished in 58~128 sec depending on the voxel size.
Conclusions: The developed gCTD package has achieved high computation efficiency on GPU for the computation of radiation dose received by a patient in a CT/CBCT scan. Clinical implementation of such a package will facilitate the patient-specific CT dose monitoring and management.

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