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  abstract = {Purpose: We propose a fast software library implemented on
    graphics processing unit (GPU) to compute digitally reconstructed
    radiographs (DRRs). It takes into account first order Compton
    scattering.
    Methods: The simulation is based on the evaluation of
    the Beer-Lambert law and of the Klein-Nishina equation. The
    algorithm is fully determinist and has been fully implemented on
    GPU to achieve clinically acceptable efficiency. A full resolution
    simulation is performed for primary radiation. A much lower image
    resolution is used for Compton scattering as it adds a low frequency
    pattern over the projection image. Each voxel of the CT dataset is
    considered as a secondary source. The number of photons that reach
    each voxel is evaluated. Then, for each secondary source, a projection
    image is computed and integrated in the final image. The photon energy
    between each secondary source and each pixel is also computed.
    An interlaced sampling mode is also proposed to further reduce
    the computation time without sacrificing numerical accuracy. Finally,
    the speed and accuracy are assessed.
    Results: We show that the computations can be fully implemented on
    the GPU with an original under-sampling method to produce clinically
    acceptable results. For example, a simulation can be achieved in less
    than 7 seconds whilst the maximum relative error remains below 5\% and
    the average relative error below 1.4\%. At full resolution, a speed-up
    by factor $\sim$12X is achieved for the GPU implementation with our
    interlaced-mode by comparison with our multi-threaded CPU
    implementation using 8 threads in parallel.
    Conclusions: DRR calculation with scatter is
    computationally intensive. The use of GPU can achieve clinically
    acceptable efficiency. A Compton fluence map can be computed in a few
    seconds using under-sampling, whilst keeping numerical inaccuracies
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}
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GPU accelerated DRR computation with scatter

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Purpose

We propose a fast software library implemented on graphics processing unit (GPU) to compute digitally reconstructed radiographs (DRRs). It takes into account first order Compton scattering.

Methods

The simulation is based on the evaluation of the Beer-Lambert law and of the Klein-Nishina equation. The algorithm is fully determinist and has been fully implemented on GPU to achieve clinically acceptable efficiency. A full resolution simulation is performed for primary radiation. A much lower image resolution is used for Compton scattering as it adds a low frequency pattern over the projection image. Each voxel of the CT dataset is considered as a secondary source. The number of photons that reach each voxel is evaluated. Then, for each secondary source, a projection image is computed and integrated in the final image. The photon energy between each secondary source and each pixel is also computed. An interlaced sampling mode is also proposed to further reduce the computation time without sacrificing numerical accuracy. Finally, the speed and accuracy are assessed.

Results

We show that the computations can be fully implemented on the GPU with an original under-sampling method to produce clinically acceptable results. For example, a simulation can be achieved in less than 7 seconds whilst the maximum relative error remains below 5% and the average relative error below 1.4%. At full resolution, a speed-up by factor 12X is achieved for the GPU implementation with our interlaced-mode by comparison with our multi-threaded CPU implementation using 8 threads in parallel.

Conclusions

DRR calculation with scatter is computationally intensive. The use of GPU can achieve clinically acceptable efficiency. A Compton fluence map can be computed in a few seconds using under-sampling, whilst keeping numerical inaccuracies relatively low. This work can be used for CBCT reconstruction to reduce scatter artifacts.

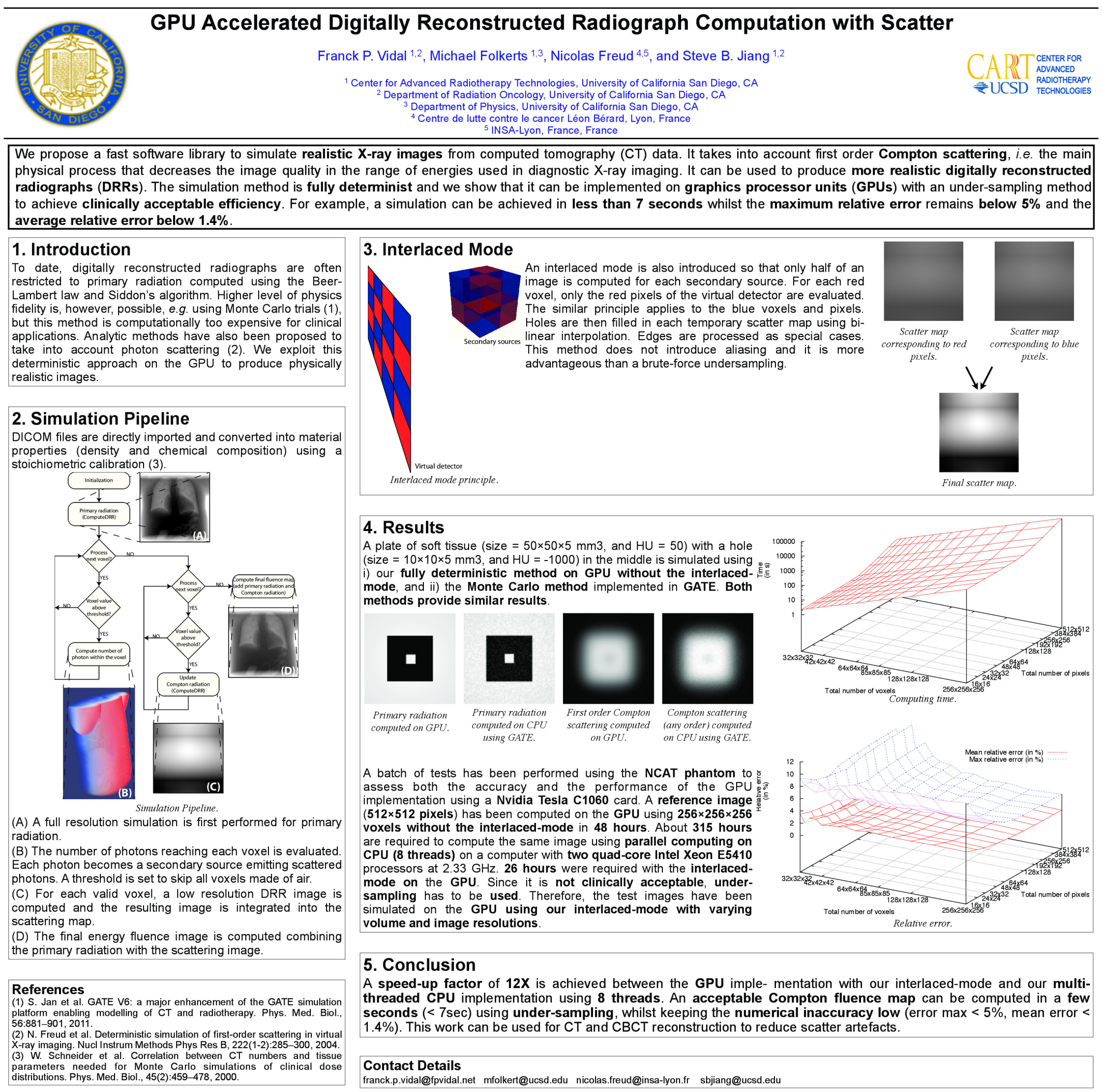

Figure 1: Poster presented at AAPM Annual Meeting, Vancouver, Canada, Jul 31–Aug 4, 2011.