SEMINAR NOTICE

Preston M. Green Department of Electrical and Systems Engineering

MULTIGPU ACCELERATION OF ITERATIVE X-RAY CT IMAGE RECONSTRUCTION

DISSERTATION DEFENSE

By

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Abstract: X-ray computed tomography is a widely used medical imaging modality for screening and diagnosing diseases, and image-guided radiation therapy treatment planning. Statistical Iterative Reconstruction (SIR) algorithms have the potential to significantly reduce image artifacts by minimizing a cost function that models the physics and statistics of the data acquisition process in X-ray CT. SIR algorithms have superior performance compared to traditional analytical reconstructions for a wide range of applications including non-standard geometries arising from irregular sampling, limited angular range, missing data, and low-dose CT. The main hurdle for the widespread adoption of SIR algorithms in multislice X-ray CT reconstruction problems is their slow convergence rate and associated computational time. We seek to design and develop fast parallel SIR algorithms for clinical X-ray CT scanners. Each of the following approaches is implemented on real clinical helical CT data acquired from a Siemens Sensation 16 scanner and compared to the straightforward implementation of the Alternating Minimization (AM) algorithm of O'Sullivan and Benac. We parallelize the computationally expensive projection and backprojection operations by exploiting the massively parallel hardware architecture of 3 NVIDIA TITAN X Graphical Processing Unit (GPU) devices with CUDA programming tools and achieve an average speedup of 72X over straightforward CPU implementation. We implement a multi GPU based voxel-driven multislice analytical reconstruction algorithm called Feldkamp-Davis-Kress (FDK) and achieve an average overall speedup of 1382X by using 3 TITAN X GPUs over the baseline CPU implementation. Moreover, we propose a novel adaptive surrogate function based optimization scheme for the AM algorithm, resulting in more aggressive update steps in every iteration. On average, we double the convergence rate of our baseline AM algorithm and also improve image quality by using the adaptive surrogate function. We extend the multi GPU and adaptive surrogate function based acceleration techniques to dual-energy reconstruction problems as well. Furthermore, we design and develop a GPU-based deep Convolutional Neural Network (CNN) to denoise simulated low dose X-ray CT images. Our experiments show significant improvements in the image quality with our proposed deep CNN-based algorithm against some widely used denoising techniques including Block Matching 3D (BM3D) and Weighted Nuclear Norm Minimization (WNNM). Overall, we have developed novel fast, parallel, computationally efficient methods to perform multislice statistical reconstruction and image-based denoising on clinically-sized datasets.

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TIME: 10:30 a.m.
PLACE: Green Hall, Room 0120

Dissertation advisor:
Dr. Joseph O'Sullivan

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