Ultrafast Multipinhole SPECT Iterative Reconstruction Using CUDA-based GPU Computing

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We have developed an ultrafast SIR method for multipinhole SPECT programmed in CUDA and tested using a high performance graphic processing unit. We show significant performance improvement in reconstruction using both computer-generated and experimental sinograms, demonstrating an up-to fifty-fold speed enhancement with virtually the same accuracy as the CPU-based SIR (with 0.15% normalized root mean square error).

Motivation

Why use GPUs for statistic iterative reconstructions (SIRs)? [1]

Pros

• High resolution with increased sensitivity compared to single pinhole or parallel hole SPECT
• Simultaneously acquired multiple views enhance accuracy
• GPU computing API

Cons

• Limited in what can actually be modeled due to constraints of CPU-based SIR
• CPU-based SIR programmed in CUDA and tested using a high-performance GPU computing API

Motivation

What's new here?

• GPU-based SIR for multipinhole SPECT using pre-computed system matrix
• Implemented using CUDA: CUSPARSE [3]
• GPU computing API
• Models finite pinhole apertures

Why multipinhole SPECT?

• Simultaneously acquired multiple views enhance accuracy
• High resolution with increased sensitivity compared to single pinhole or parallel hole SPECT
• Potential lower resolution tradeoff

CPU vs. GPU Implementations

<table>
<thead>
<tr>
<th>Hardware / Method</th>
<th>GPU</th>
<th>CPU</th>
</tr>
</thead>
<tbody>
<tr>
<td>Processing center</td>
<td>1 core of an AMD Opteron 6128 2.0 GHz (CPU)</td>
<td>448 cores of a NVIDIA Tesla M2070 (GPU)</td>
</tr>
<tr>
<td>RAM</td>
<td>16 GB</td>
<td>6 GB</td>
</tr>
<tr>
<td>Sparse matrix operations (projections)</td>
<td>CUSPARSE 3.1.2 [1]</td>
<td>CUSPARSE 3.1.2 [1]</td>
</tr>
<tr>
<td>Rotation, correction, and evaluation operations</td>
<td>CUDA-based CUDA-based</td>
<td></td>
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</tbody>
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Maximum-likelihood expectation maximization (MLEM)

MLEM SIR algorithm

Ray-tracing

System matrix generation

SIR Setup

Projections from digital phantoms

Hot rod phantom

MOBY phantom [6]

Projections from experimental acquisitions

Mouse heart phantom [7]