A GPU Accelerated Moving Mesh Correspondences with Application to Right Ventricular Segmentation

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Introduction

This study presents an accelerated moving mesh correspondence based segmentation algorithm using GPU computing.

The moving mesh correspondence algorithm [1] has been shown to be effective for automated delineation of the right ventricle (RV) from a sequence of cardiac magnetic resonance (MR) images [2].

Given the segmentation on the first frame, the proposed method segments both endocardial and epicardial borders of the RV using the obtained point correspondence and relaxes the need of a training set.

Implementation

The algorithms were implemented using the Python Programming Language.

The GPU CUDA version was implemented using Numbapro (Continuum Analytics, Austin, TX) python module.

The moving mesh algorithm also uses Numbapro CUDA submodules: cufft and cublas.

Data

The proposed method was evaluated over the Training data set provided by the MICCAI 2012 RV segmentation challenge (http://www.litislab.eu/rvsc/).

The data set consists of short-axis MRI volumes of 16 subjects.

The data was acquired on 1.5T MR scanners (Symphony Tim, Siemens Medical Systems, Erlangen, Germany) with steady-state free precession acquisition mode.

Moving Mesh

Computes similarity metric (SSD)

Compute gradients w.r.t. m & g

Optimization

Update parameters (m & g)

Compute parameters (from m & g to deformation)

Deformed template

Template

Study

Diffeomorphic Nonrigid Registration

Segmentation Results

Figure: Representative example showing the results of the moving mesh algorithm.

Frame 1 frame 2 frame 3 frame 4 frame 5

Frame 6 frame 7 frame 8 frame 9 frame 10

Frame 11 frame 12 frame 13 frame 14 frame 15

Frame 16 frame 17 frame 18 frame 19 frame 20

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Moving Mesh

The GPU version of the algorithm yielded increased computational savings as the images become larger.

The computational cost of the GPU version was approximately constant, whereas the CPU version increased linearly with the number of pixels.

As a future work, we are planning to stitch multiple images together and compute the moving mesh to optimize the CUDA performance.

Performance

<table>
<thead>
<tr>
<th>Implementation</th>
<th>Moving mesh computation</th>
</tr>
</thead>
<tbody>
<tr>
<td>GPU (python+numbapro)</td>
<td>6.41 ± 0.36 seconds</td>
</tr>
<tr>
<td>CPU (python)</td>
<td>3991.70 ± 1456.78 seconds</td>
</tr>
<tr>
<td>CPU (python+numbapro)</td>
<td>35.69 ± 26.55 seconds</td>
</tr>
</tbody>
</table>

*Evaluated only over one subject due to very large runtimes.

References
