Segmentation and tracking algorithms on parallel hardware

Arunachalam Narayanaswamy*, Saritha Dwarakapuram*, Chris Carothers*, Barbera Cutler*, Chris Bjornsson†, William Shain†, Ellen Robey and Badrinath Roysam*

Department of Electrical Engineering*, Computer Science † and Biomedical Engineering†, Rensselaer Polytechnic Institute, Troy

Center for Neural Communication Technology ‡, Wadsworth Center, Albany

Department of Molecular and Cell Biology, University of California, Berkeley

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Abstract

We present a GPU implementation of the Vessel Surface segmentation algorithm we developed using robust hypothesis testing and an adaptive region growing algorithm. We also extract the centerlines from the surface segmentation. We provide a comparison of our results with the existing Hessian filtering based technique and achieved an 8X speed up with the GPU implementation. We also present our work on Cell segmentation and tracking that runs on the BlueGene Supercomputer at RPI. This achieves a speedup of upto 600X to unmix, segment and track a series of 764 3-D images. This greatly reduces the feedback time enabling us to try out new algorithms to segment and track cells.

Significance

Segmenting blood vessels tagged by EBA is an important element of neuroscience and stem cell research. Segmentation of cell nuclei and tracking is of huge importance in immunology and cancer research.

Challenge

• Low contrast, broken signal, huge 3D images => difficult to manually validate
• Huge memory requirement a challenge in a GPU implementation.
• Achieving cell segmentation and tracking in a BlueGene supercomputer has issues with both memory and requires a highly parallel data design for high speeds.

State-of-the-Art

• Robust 3-D Modeling of Vasculature Imagery Using Superellipsoids
• Spatio-temporal cell cycle phase analysis using level sets and fast marching methods

Technical Approach

Vessel segmentation on GPU: 3-D data sets containing separate five data channels in 100µm thick tissue slices was collected using spectral unmixing techniques. Typical dataset size: 1024x1024x60.

Generalized likelihood ratio based hypothesis testing was used for vessel detection step.

Cell Segmentation and Tracking

We developed a parallel implementation of the cell segmentation and tracking using MPI libraries and tested it in the BlueGene Supercomputer at RPI. The segmentation and tracking was done over 764 3-D image stacks and the speedup achieved was over 600X from a serial computer. The work is in progress and we hope to develop and test various segmentation and tracking algorithms much faster since the computational time for such a large dataset is less than 2 minutes.

References


Contact info.

Badrinath Roysam, Professor
Dept. of Electrical, Computer, and Systems Engineering
Rensselaer Polytechnic Institute, 110 8th Street, Troy, NY 12180
Phone: (518)276-8067; Fax: 518-276-8715;
Email: roysam@ecse.rpi.edu

(A) The two hypotheses (B) maximum-intensity projection of the original 3-D confocal dataset that is contrast stretched to better show the imaging noise and overlap from the nuclear channel (small circular objects). (C) Adaptive Otsu thresholding; (D) Hessian filtering (E) Tube tracing results [4]; (F) Basic surface extraction algorithm described in Section D; (G) Results of adaptive contiguous extension (Section E). These 2 panels have the same sensitivity (true positive rate).

Illustrating the parallel implementation in GPU (A) A table showing the performance results in CPU/GPU (B) A flowchart of the surface segmentation algorithm with ACE. We implemented 5 different kernel functions to achieve a parallel implementation in the GPU.