ASSEMBLING LARGE MOSAICS OF ELECTRON MICROSCOPY IMAGES USING GPU

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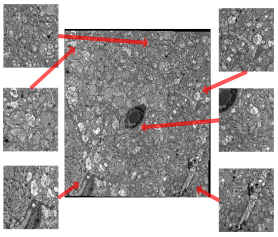
MOTIVATION

The Neural Circuit Reconstruction (NCR) Toolkit is used to register and warp thousands of images of Transmission Electron Microscope into volumes [1,2]. In the current toolset exporting the aligned mosaic images from the original images is a bottleneck in the process when terrabytes of images need to be mapped. We accelerated this process using GPU.

RESULTS

Programming model	Machine details	Time elapsed (in seconds)	Speed up
Single threaded C	Intel Core 2 Quad CPU Q9550 @ 2.83 GHz	2022.3	N/A
OpenMP multithreaded (16 threads)	Intel Core 2 Quad CPU Q9550 @ 2.83 GHz	1140.46	1.77x
ITK based and multi-threaded [5]	Intel Core 2 Quad CPU Q9550 @ 2.83 GHz	120	16x
NVIDIA CUDA	Intel Core 2 Quad CPU Q9550 @ 2.83 GHz & NVIDIA GeForce GTX 280	10.8	187.23x



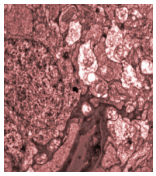
METHOD

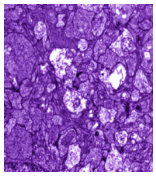
(Input 1) Grid transform file

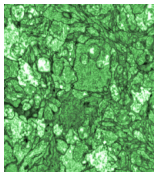
- Warped Tile image parameters
- Non-uniform transform parameters

(Input 2) EM Tiles

- Heating by the electron beam causes distortion of the tile







Courtesy: Marc Lab

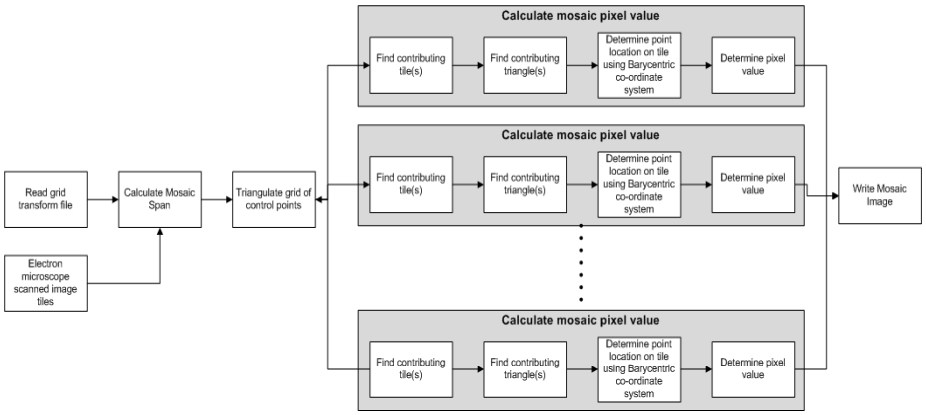
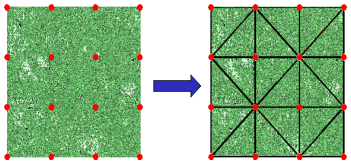


Figure M4: Processing pipeline to determine value of every pixel in the mosaic

(Step 1) Calculate mosaic bounds

(Step 2) Triangulate grid of control points



(Step 3) Find contributing image tiles for every pixel in mosaic

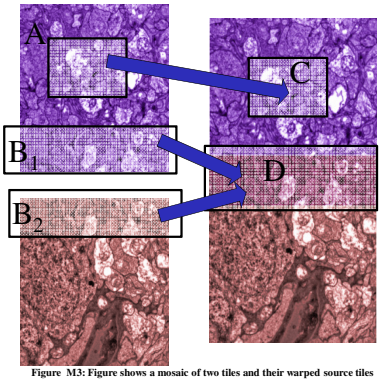
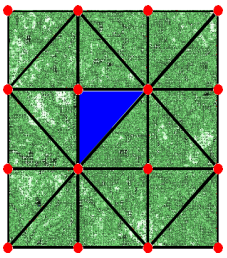
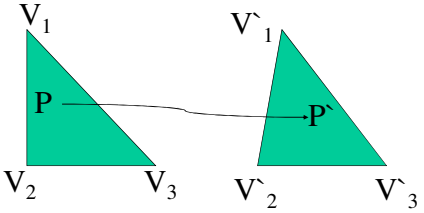


Figure M3: Figure shows a mosaic of two tiles and their warped source tiles

(Step 4) Find contributing triangle



(Step 5) Determine pixel location using Barycentric co-ordinate system



(Step 6) Determine pixel value using nearest neighbor interpolation

OPTIMIZATIONS

Interpolation

Tiles are loaded into texture memory. Random access to texture memory is optimized by the texture caching process. Random access is required because the tile is non-linearly distorted.

GPU data copy cost minimization

Copying data from CPU to GPU is costly. A queuing process replaces the earliest used texture with required texture minimizing texture copies.

References:

[1] J.R. Anderson, B.W. Jones, J.-H. Yang, M.V. Shaw, C.B. Watt, P. Koshevoy, J. Spaltenstein, E. Jurrus, Kannan U.V., R.T. Whitaker, D. Mastronarde, T. Tasdizen, R.E. Marc. **"A Computational Framework for Ultrastructural Mapping of Neural Circuitry,"** In *PLoS Biology*, Vol. 7, No. 3, pp. e74. 2009.

[2] Pavel A. Koshevoy, Tolga Tasdizen, Ross T. Whitaker, April 19, "**Automatic assembly of TEM mosaics and mosaic stacks using phase correlation:**", 2007, SCI technical report

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