High Speed Data Processing for Optical Coherence Tomography

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Abstract

OCT is a non invasive three dimensional imaging approach that offers high resolution, high speed, and 1-2mm penetration depth in biological tissue. Functionally, it is often compared to ultrasound, in that it detects signals reflected by features of a sample. A Fourier domain approach to OCT has become popular due to advantages in imaging speed and signal to noise ratio¹. However, transforming frequency domain volumes of raw data to user viewable images is a computationally intensive multi-step process, and due to the technology’s high imaging speed, is usually the bottleneck in a user’s workflow.

Background

(a) OCT uses a Michelson interferometer to scan a sample and acquire images. The resulting data requires considerable processing to generate images. (b) Processed cross sectional image of a mouse embryo. (c) Image stacks are constructed from individual A-Scans (axial depth scans).

Problem

- There are 40,000 to 1,000,000 A-Scans in a single image stack.
- Sequential processing of data takes ~1-10 minutes per stack, but only seconds to acquire.
- Desirable to have real time image processing capability.
- A solution is possible because every A-Scan is independent and each A-Scan needs the same exact set of operations performed on it.

Solution

- Parallel processing on the GPU is extremely well suited for the task.
- Port MATLAB code to CUDA C++ to utilize processing power of GPU.
- Optimize GPU kernels with nVidia Visual Profiler.
- Overlap data reading and processing.

(d) A typical CPU has 2 to 4 cores limiting parallel processing capability. A typical GPU has thousands of processing cores.
(e) GUI developed for the app.

Features / Software Flowchart

- 25x higher speed than CPU solution.
- Batch processing of multiple files or folders.
- Automatic¹ or manual dispersion compensation modes.
- Selectable preview frequency.
- Selectable batch sizes for A & B-Scans.
- Save as cross-section or en-face.

Results

A-Scan Processing Rate

- 25x Faster

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Members of Z-lab, Prof. Chao Zhou, Dr. Aneesh Alex, Yongyang Huang, Charly Caredda. Image credit: Yongyang Huang.

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