Hardware Efficient Image Reconstruction for Two-Photon Microscopy

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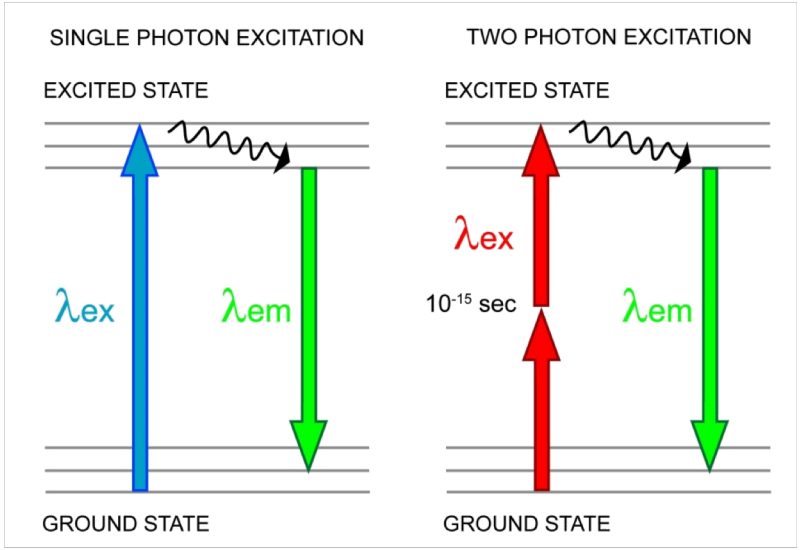
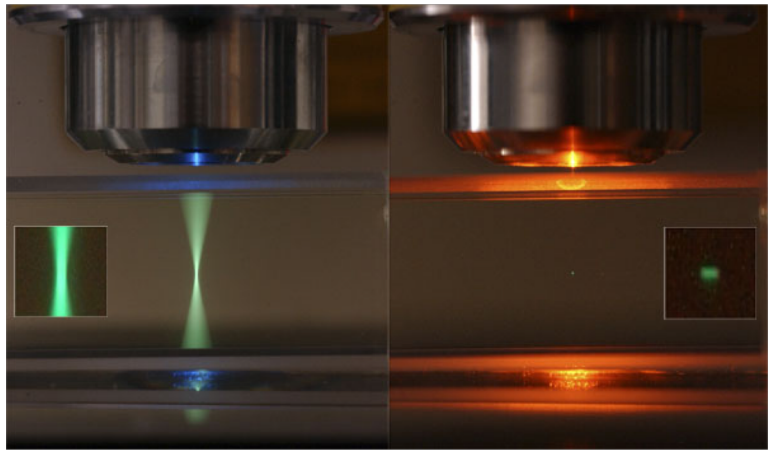
What is a Two-Photon Microscope?

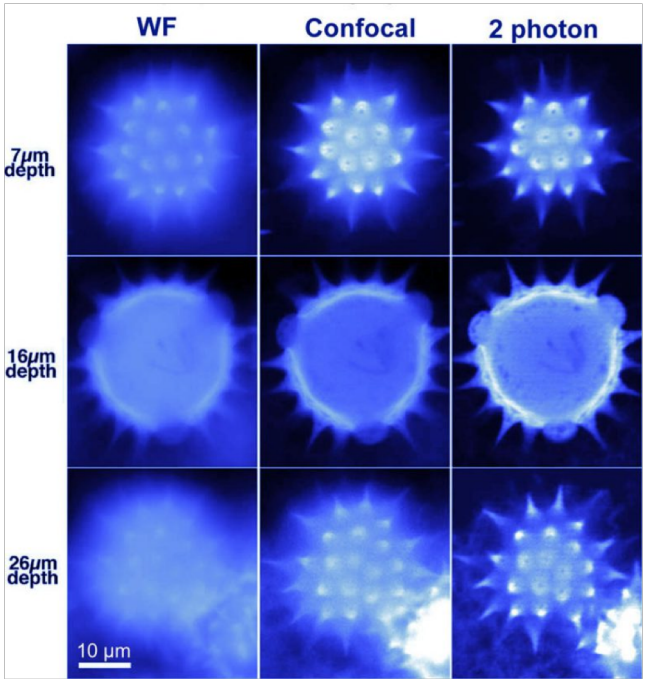
- Area of interest is marked with dye or fluorescent molecular “probe”
- A (infrared) laser excites the a single pixel in the region of interest
- A light sensor captures the resulting intensity, and the point is “scanned”
- Intensity values are then used to produce the image of that area



Tighter Excitation Leads to Better Resolution

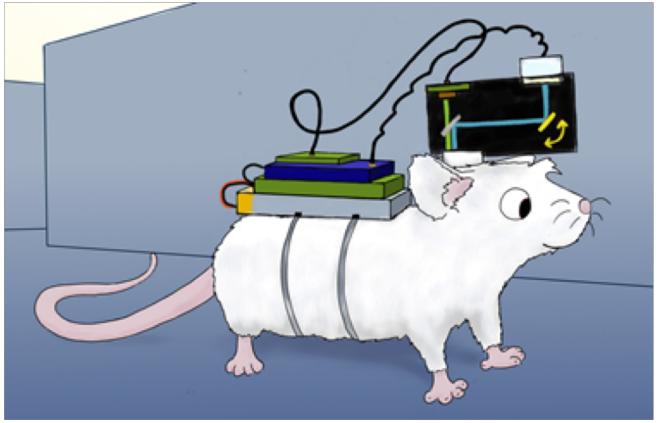


Two-photon phenomena leads to tighter excitation volumes and leads to better images



Building a Wireless Two-Photon Microscope

- Wireless device that can be mounted on a freely moving organism
  - Enable more meaningful experiments
- Miniaturization of all components
  - Requires efficient software/hardware integration
  - Alternative computational paradigms



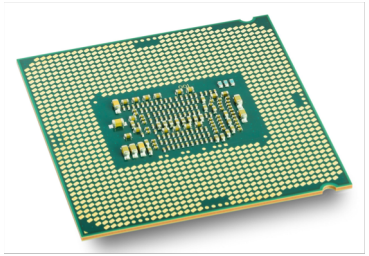
Data Processing Computational Strategies

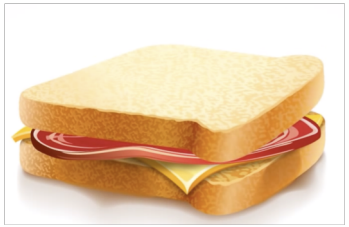
- CPU is poorly suited to processing the raw data coming from the microscope
  - CPU is better at diverse sets of computation

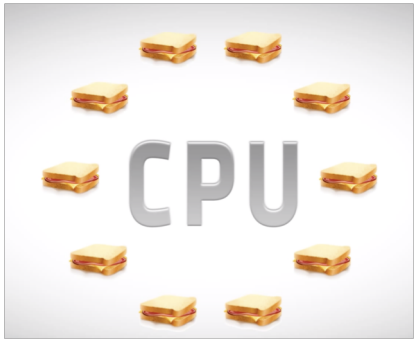
- GPU can perform data processing more quickly!
  - GPU is better at performing simple and parallelizable computations

Parallel Programming Analogies

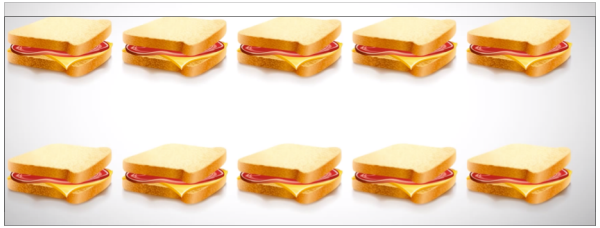
Imagine you want to make 10 sandwiches and each sandwich takes 5 seconds







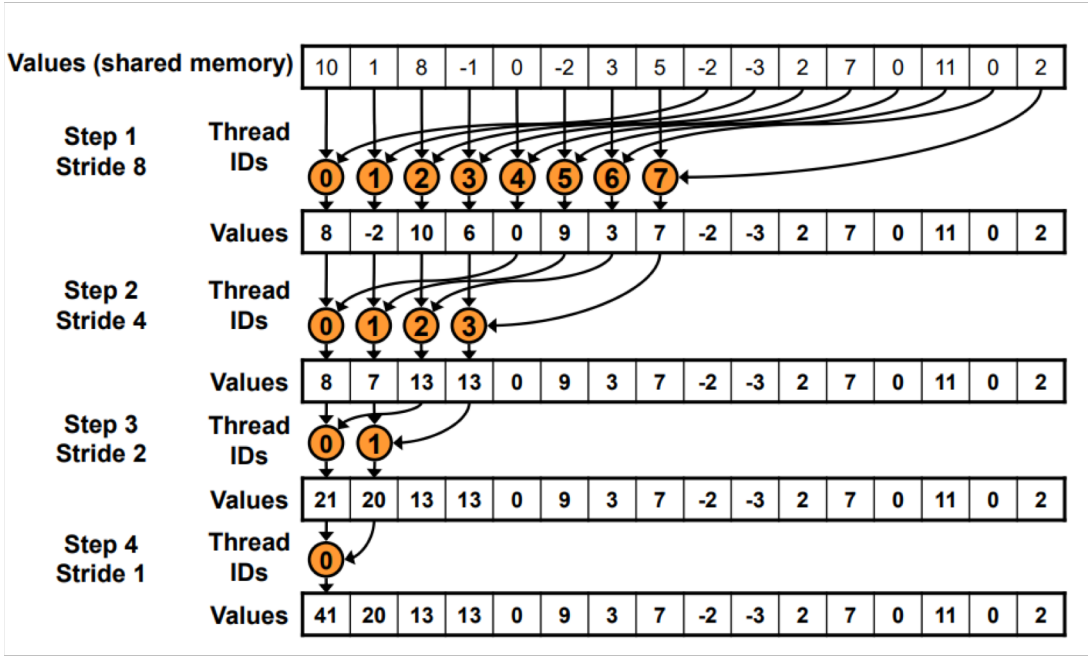
~50 seconds



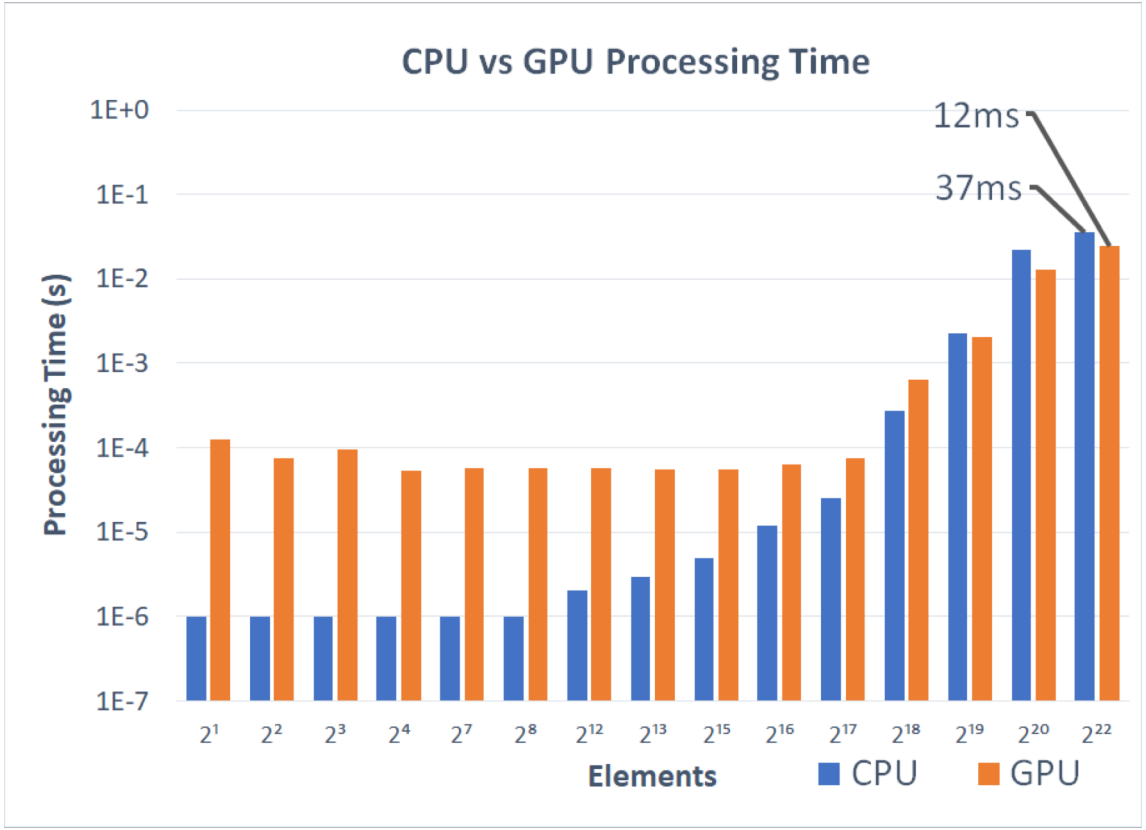
~5 seconds

How Parallelism Can Be Applied to Our Problem

- The light sensor picks up intensity values that determines the brightness of each pixel
  - Compute integral of intensity values
- “Thread” executions are independent of each other
- Speedup comes from massive parallelism



Performance Comparison



The GPU Outperforms The CPU While Processing Large Data Sets

- A sample 1 GB data set was processed in ~12 ms (93 GB/s)!
  - CPU performs same task in ~37ms
- Data rate expected: 4.8 GB/s

Future Goals

- Integrate the algorithm into a Two-Photon Microscope to measure real data output from our Two-Photon Microscope

Thank you!

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