Near Real-Time Deconvolution for 3D Fluorescence Microscopy

Marc Bruce, PhD
CEO, Microvovation
Microvovation offers faster and more accurate deconvolution
Basics of Fluorescence Microscopy

Sample

Objective
Basics of Fluorescence Microscopy

Illumination

Dichroic mirror
Basics of Fluorescence Microscopy

Emission
Basics of Fluorescence Microscopy

- Damage to sample from high intensity light
- Haze from out-of-plane fluorescence
- Blurriness due to diffraction reduces resolution of small objects

Derived from Wikipedia, “Light sheet fluorescence microscopy”
Diffraction Limits 3D Resolution
Point Spread Function
The Solution: Deconvolution Software

Observed = True * Blur + Noise

\[
\frac{\text{Observed}}{\text{Blur}} \neq \text{True}
\]

http://www.leica-microsystems.com/science-lab/deconvolution
Richardson Lucy Algorithm

Iterative algorithm operating under the assumptions of Poisson-distributed noise

Observed = True * Blur + Noise

\[ g = f * h + \varepsilon \]

\[ f^{i+1} = f^i \cdot \left( \frac{g}{f^i * h} * \hat{h} \right) \]
Real-time Deconvolution is Now Possible

- GPU yields speeds up to 200X faster than old methods
- Allows for real-time deconvolution
  - Optimize image capture
Higher Signal-to-Noise Ratio Yields Better Data

- Analysis of raw FRET images showed low contrast
- 4x effective increase in contrast post-deconvolution
- Expected cell features can now be seen

Diffraction-Limited Resolution Limit
Increased Resolution to 180 nm

Tong Zhang and Puifai Santisakultarm, Salk Institute
Microscopy in Dim Light

Before
2048 x 2048 x 51

After 3D Deconvolution
8.5 seconds

Image Courtesy of Technical Instruments
Widefield Microscopy

Widefield Image Before
1024 x 1024 x 34

After 3D Deconvolution
1.6 seconds
Light Sheet Microscopy

Derived from Wikipedia, “Light sheet fluorescence microscopy”
Light Sheet Microscopy

Light Sheet Image Before
946 x 768 x 321

After 3D Deconvolution
22.5 seconds

Dong-Yuan Chen in the Bilder lab, UC Berkeley
Lattice Light Sheet Microscopy

LLSM Before
1167 x 512 x 401

After 3D Deconvolution
10.2 seconds
Instant SIM

Instant SIM Image Before
1446 x 1131 x 14

After 3D Deconvolution
4.9 seconds
FINCH (Fresnel incoherent correlation holography)

Widefield Image
2048 x 2048 x 21

After Propagation and 3D Deconvolution
10 seconds

Usable on All Tiers of GPUs

- **HPC clusters**
  - Split large multi-channel, multi-timepoint images onto independent nodes
  - Let peer GPUs collaborate

- **Desktops**
  - Run alongside acquisition

- **Embedded systems**
  - Currently developing for TX1
Usable on All Tiers of GPUs

![Graph showing comparison of different GPUs for various resolutions, with TX1, K2200, 970M, K40, P5000, P5000, and GP100.](image-url)
Questions?

Marc Bruce
marc@microvolution.com