

## Morphological restoration: A fast alternative to deconvolution of cells in 3D images

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01/10/2016

**Morphological restoration: A fast alternative to deconvolution of cells in 3D images**

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**1. Introduction**

Multiphoton microscopy (MPM) is a powerful tool for intravital imaging. However, the point spread function (PSF) leads to shape elongation along the optical axis, which can mislead the analysis of cell interactions. Deconvolution is crucial to restore objects shape but is extremely time-consuming.

**2. Alternative approach: Morphological restoration**

The workflow involves microscopy, deconvolution, segmentation, and morphological restoration. The restoration process uses a model of the cell shape to fit the observed data, resulting in a more accurate representation of the cell's morphology.

**3. Fitting PSF-caused extension from synthetic spheres**

Parameters for synthetic spheres include diameter (10-20 µm), axial resolution ( $\sigma_{ax}$ ), and overlap error ( $E_{ov}$ ). The restoration process involves fitting the observed data to a model of the cell shape.

**4. Simulation workflow**

The simulation workflow includes simulation, adding noise, deconvolution, segmentation, morphological restoration, and performance evaluation. The restoration process is significantly faster than deconvolution.

**5. Estimation of PSF from the "average cell"**

The PSF is estimated from the average cell. The process involves measuring the cell's size and shape, and fitting the observed data to a model of the cell shape.

**6. Restoration results: Synthetic ellipsoids**

Restoration results for synthetic ellipsoids show that morphological restoration is significantly faster and more accurate than deconvolution. The restoration process is able to restore the original shape of the cells, even in the presence of noise.

**7. Restoration results: Synthetic cells with realistic shapes**

Restoration results for synthetic cells with realistic shapes show that morphological restoration is significantly faster and more accurate than deconvolution. The restoration process is able to restore the original shape of the cells, even in the presence of noise.

**8. Restoration results: Synthetic multicellular stacks of ellipsoids**

Restoration results for synthetic multicellular stacks of ellipsoids show that morphological restoration is significantly faster and more accurate than deconvolution. The restoration process is able to restore the original shape of the cells, even in the presence of noise.

**9. Restoration results: Experimental data**

Restoration results for experimental data show that morphological restoration is significantly faster and more accurate than deconvolution. The restoration process is able to restore the original shape of the cells, even in the presence of noise.

**Summary**

Morphological restoration vs. ImageJ:  
 - considerably faster  
 - comparable accuracy in smaller z-spacings  
 - less accurate in larger z-spacings

**Outlook**

Optimization for larger z-spacings, comparison with other deconvolution software, and open source software package.

**References**

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