DeconvTest: in silico microscopy framework to evaluate the accuracy of deconvolution

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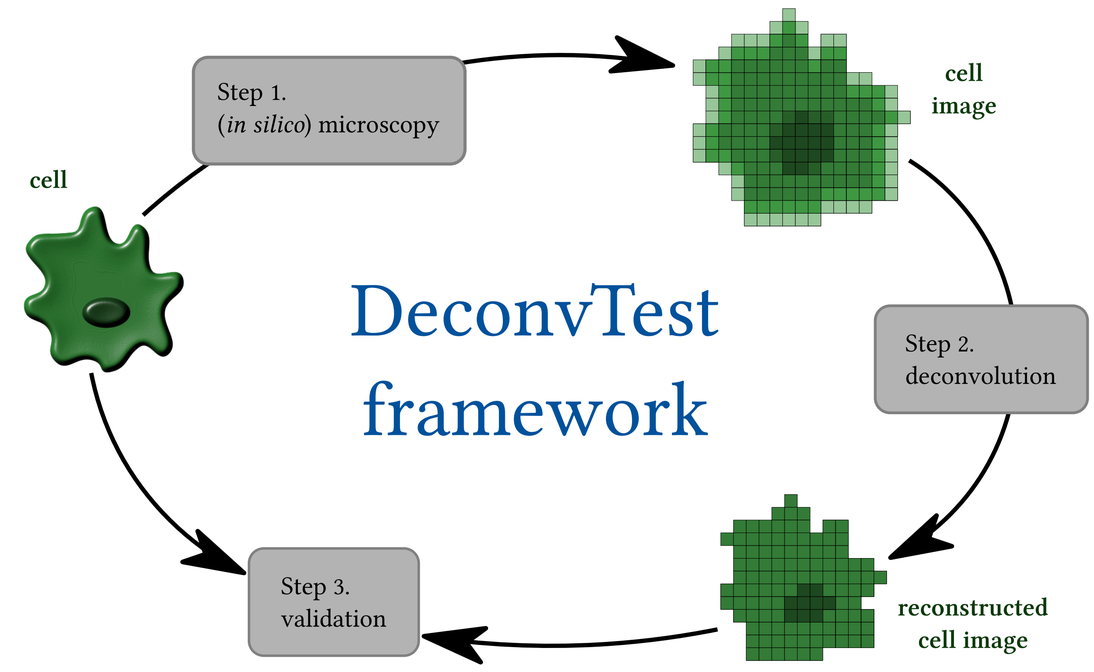
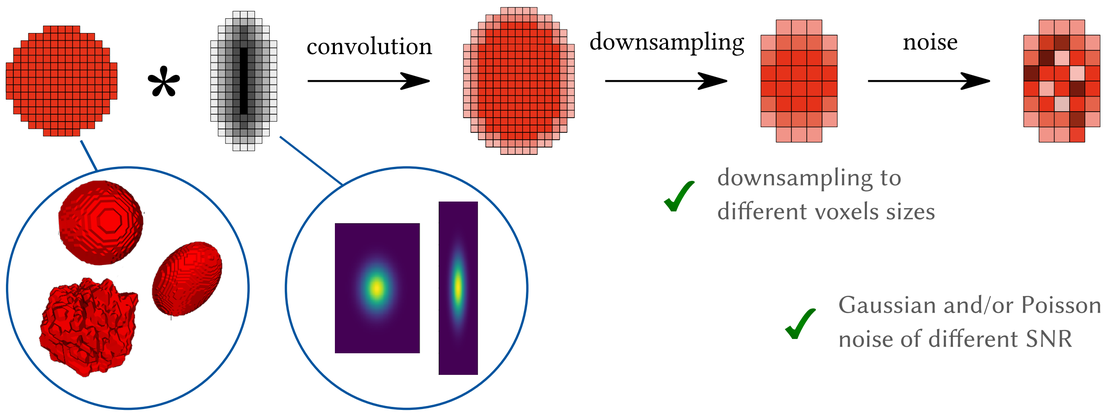
1. Introduction



- ✓ python-based simulation framework
- ✓ parallel-computation
- ✓ compares performance of different deconvolution algorithms

2. Methods

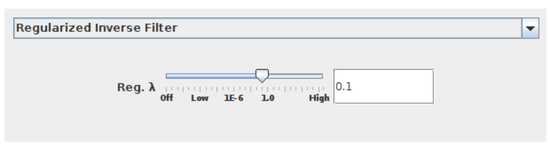
Step 1. *in silico* microscopy



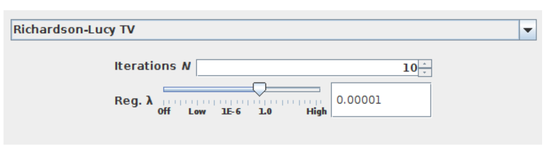
- ✓ downsampling to different voxels sizes
- ✓ Gaussian and/or Poisson noise of different SNR
- ✓ cells of different size and shape
- ✓ Point spread functions (PSFs) of different width (σ) and aspect ratio (E)
- ✓ simulation parameters specified via a settings file

Step 2. Deconvolution

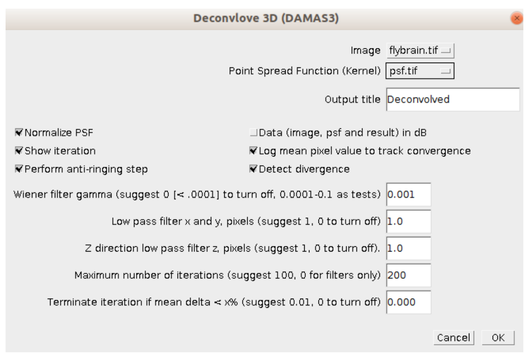
ImageJ / Fiji deconvolution plugins run from python in a parallel manner:



- ✓ DeconvolutionLab2 [1]: Regularized Inverse Filter (RIF)

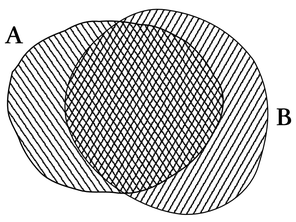


- ✓ DeconvolutionLab2 [1]: Richardson-Lucy Total Variance (RLTV)



- ✓ Iterative Deconvolve 3D (DAMAS3) [2]

Step 3. Validation



Jaccard index

$$J = \frac{A \cap B}{A \cup B}$$

Sensitivity

$$S = \frac{A \cap B}{A}$$

Precision

$$P = \frac{A \cap B}{B}$$

Overlap error

$$E_o = \frac{A \cup B - A \cap B}{A}$$

Overdetection error

$$\mathrm{Od} = \frac{A \cup B - A}{A}$$

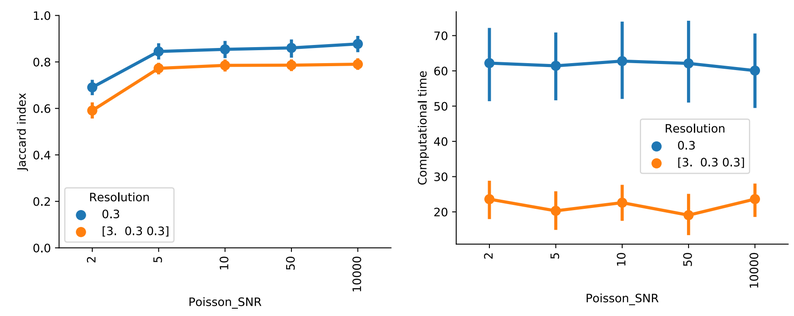
Underdetection error

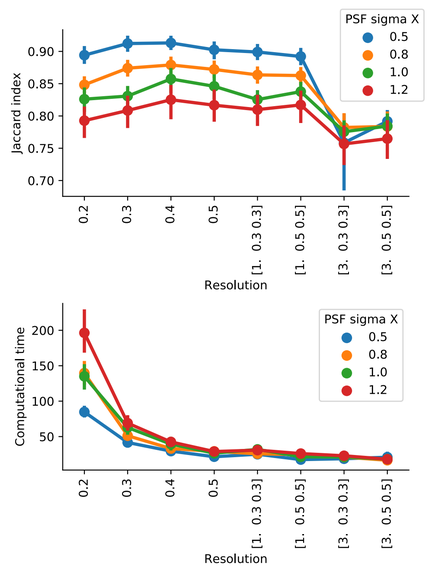
$$\mathrm{Ud} = \frac{A \cup B - B}{A}$$

3. Results

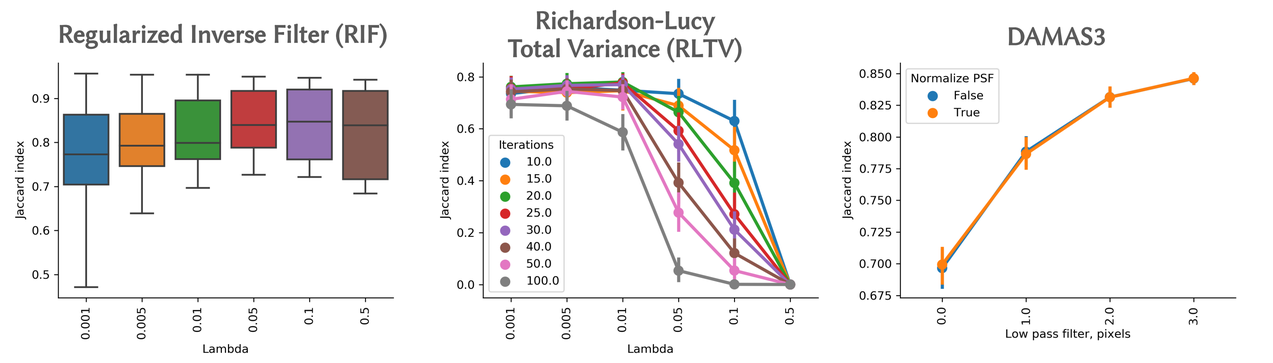
Influence of different parameters of *in silico* microscopy

Richardson-Lucy Total Variance (RLTV)

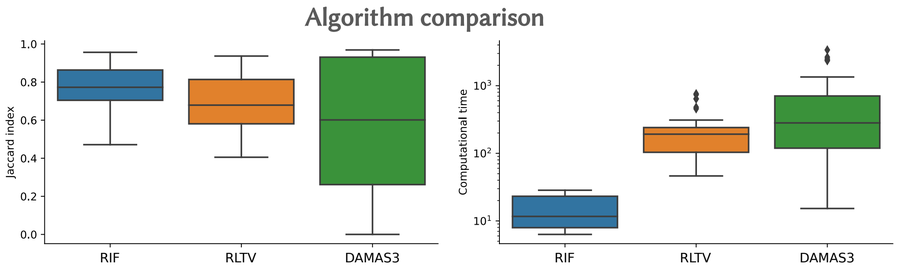




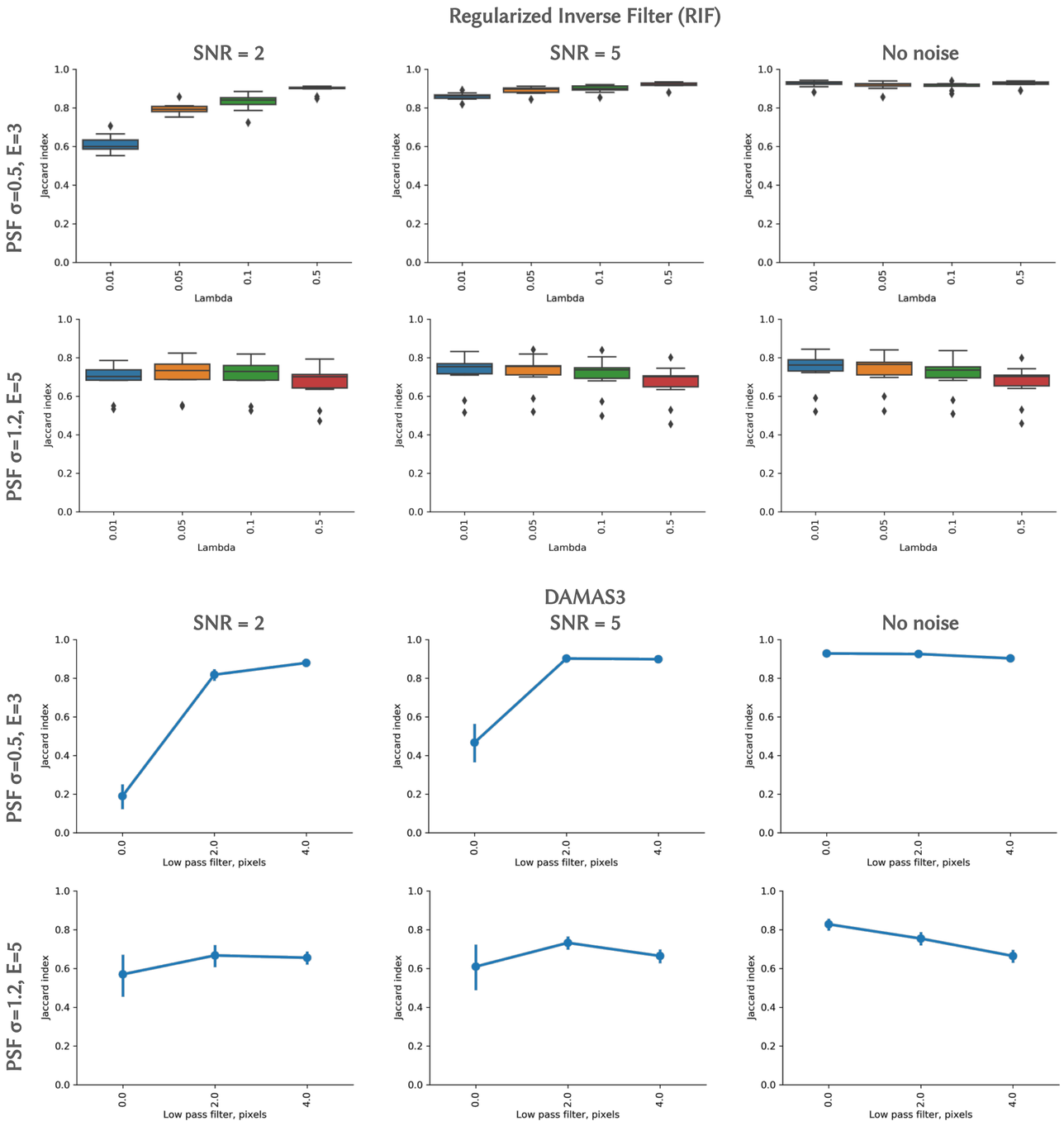
Comparison of deconvolution approaches and their settings



- Convolution: $f * g + \epsilon = h$
- Inverse filter: $F = \frac{H}{G}$
  F, G, H – Fourier transform of f, g, h
- Regularized Inverse Filter (RIF):
  $F = H \cdot \frac{G}{|G|^2 + \lambda \cdot |L|^2}$
  L – derivative of G



Choosing optimal deconvolution settings



4. Outlook

- Open source package on GitHub
- Include other types of input cells and PSFs
- Include further deconvolution algorithms

References:

[1] Sage, D. et al. "DeconvolutionLab2: An open-source software for deconvolution microscopy", (2017) Methods 155: 28-41.
[2] Dougherty, R. "Extensions of DAMAS and Benefits and Limitations of Deconvolution in Beamforming," (2005) American Institute of Aeronautics and Astronautics

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