DECONVOLUTION

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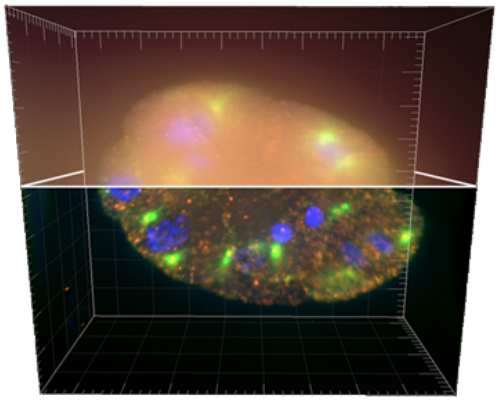
DeconvolutionLab2

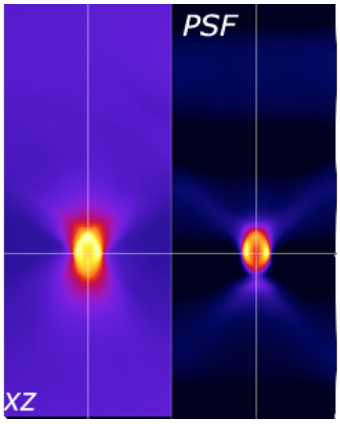
The remasterized Java deconvolution tool

DeconvolutionLab2 is freely accessible and open-source for 3D deconvolution microscopy; it can be linked to well-known imaging software platforms, **ImageJ**, **Fiji**, **ICY**, **Matlab**, and it runs as a stand-alone application.

The backbone of our software architecture is a library that contains the number-crunching elements of the deconvolution task. It includes the tool for a complete validation pipeline. Inquisitive minds inclined to peruse the code will find it fosters the understanding of deconvolution.

At this stage, DeconvolutionLab2 includes a friendly user interface to run the following algortihms: Regularized Inverse Filter, Tikhonov Inverse Filter Naive Inverse Filter, Richardson-Lucy, Richardson-Lucy Total Variation, Landweber (Linear Least Squares), Non-negative Least Squares, Bounded-Variable Least Squares, Van Cittert, Tikhonov-Miller, Iterative Constraint Tikhonov-Miller, FISTA, ISTA.





Reference

D. Sage, L. Donati, F. Soulez, D. Fortun, G. Schmit, A. Seitz, R. Guiet, C. Vonesch, M. Unser
DeconvolutionLab2 : An Open-Source Software for Deconvolution Microscopy
Methods-Image Processing for Biologists, vol. 115, 2017.

Installation of DeconvolutionLab2

Download		
DeconvolutionLab_2.jar	Version 08.05.2017	Do not unzip this downloaded file

Installation

Command line interface

1. To run the user interface of Deconvolutionlab2, enter the following command line in the terminal:

```
java -jar DeconvolutionLab_2.jar Lab
```

2. To run a deconvolution task with a command following this example:

```
java -jar DeconvolutionLab_2.jar Run
-image synthetic Cube 10.0 1.0 size 200 100 100
-psf synthetic Double-Helix 3.0 30.0 10.0 size 200 100 100 intensity 255.0
-algorithm RIF 0.1000 -out mip MI1 -path home
```

Put the file DeconvolutionLab_2.jar in the **plugins** folder and restart ImageJ or Fiji. Check the menu Plugins » DeconvolutionLab2.

ImageJ	1. » DeconvolutionLab2 Lab: Start the complete user interface of DeconvolutionLab2
	2. » DeconvolutionLab2 Run: Run headless a deconvolution command given as a macro
	3. » DeconvolutionLab2 Launch: launch the GUI for a deconvolution command provided as a macro
	Example of ImageJ macro
	`image = " -image synthetic Cube 10.0 1.0 size 200 100 100"`
	`psf = " -psf synthetic Double-Helix 3.0 30.0 10.0 size 200 100 100"`
	`algorithm = " -algorithm RIF 0.1000 -out mip MI1 -path home"`
	`run("DeconvolutionLab2 Launch", image + psf + algorithm + parameters)`

ImageJ2	
Fiji	
Matlab	Add DeconvolutionLab_2 in the java path javaaddpath([matlabroot filesep 'java' filesep 'DeconvolutionLab_2.jar']) then run a specific algorithm result = DL2.RIF(image, psf, 0.125 , '');
Stand-alone application	If you have a Java JDK properly installed in your machine, double-click on the DeconvolutionLab_2.jar file to the start the user interface of Deconvolutionlab2.

Java code	Use the DeconvolutionLab2 as a Java library
	Snippet of Java code
	`RealSignal r = Lab.getImage("fundus.tif");`
	`RealSignal h = new DirectionalMotionBlur(2, 20, 20).generate(r.nx, r.ny, r.nz);`
	`Simulation sim = new Simulation(0, 1, 0);`
	`RealSignal y = sim.run(r, h);`
	`TikhonovRegularizedInverseFilter trif = new TikhonovRegularizedInverseFilter(0.001);`
	`RealSignal x = trif.run(y, h);`
	`Lab.show(x, "TRIF " + i);`

Icy	Not yet ready for the centralized distribution on the Icy website

Source code and documentation	
GIT Repository	git clone https://c4science.ch/diffusion/2075/deconvolution.git
Status	**Status of the development**
API	**Java doc**

FFT Libraries		
JTransforms	Visit the page of **JTransforms** JTransforms is already included in Fiji and Icy	Get a JTransforms.jar file and put it in the same directory than DeconvolutionLab_2.jar
FFTW Version 2	**FFTW.zip** It is include the FFTW2 dynamic libraries for Mac OSX, and Windows 32-bits and 64-bits machines, and Linux 32-bits and 64-bits machines.	Download the FFTW.zip folder, unzip it and put it in the same directory than DeconvolutionLab_2.jar

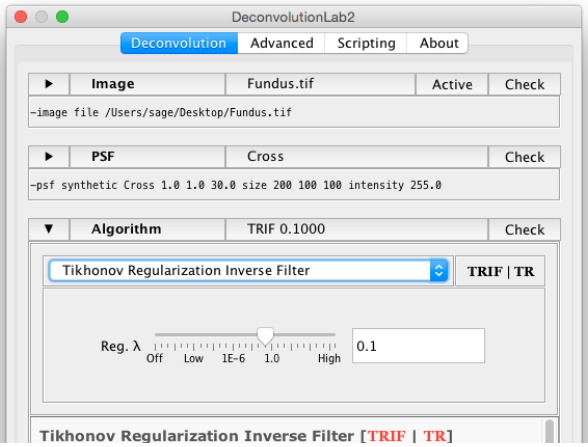
How to use Deconvolution2

▶ Image

Drag and drop Drag and drop the input image file (or directory) into the Image bar or in the image table

`file` Select a file containing a z-stack of images (default path is indicated in Path)

`directory` Select a directory containing the list of images (only files which have a name containing the pattern)



`synthetic`	Create a synthetic image by choosing its shape, size, and intensity
`platform`	Select one of the open images of the platform (ImageJ)
`active`	Select the active image window of the platform (ImageJ)

▶ PSF

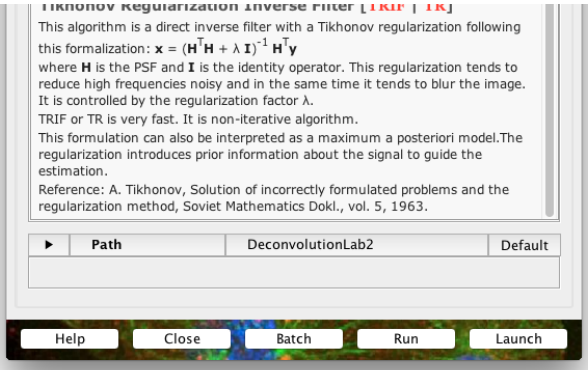
Drag and drop	Drag and drop the PSF image file (or directory) into the PSF bar or in the PSF table
`file`	Select a file containing a z-stack of images (default path is indicated in Path)
`directory`	Select a directory containing the list of images (only files which have a name containing the pattern)
`synthetic`	Create a synthetic PSF by choosing its shape, size, and intensity
`platform`	Select one of the open images of the platform (ImageJ)
`active`	Select the active image window of the platform (ImageJ)

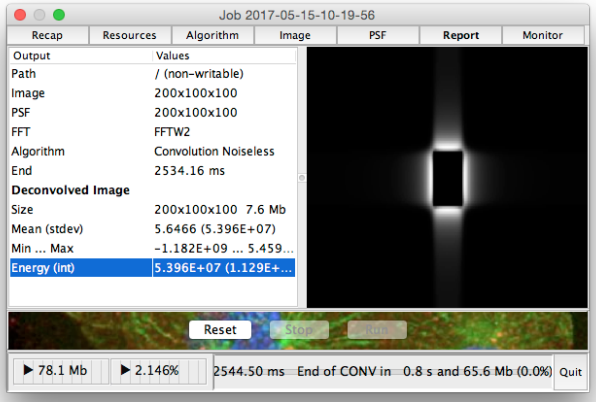
▶ Algorithm

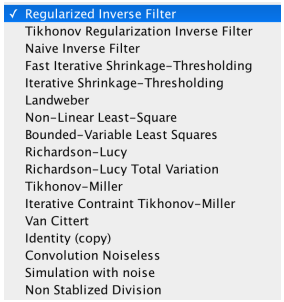
- Choose an algorithm
- Select the parameters

▶ Path

- Drag and drop a directory used as working directory
- Select the current directory as main directory







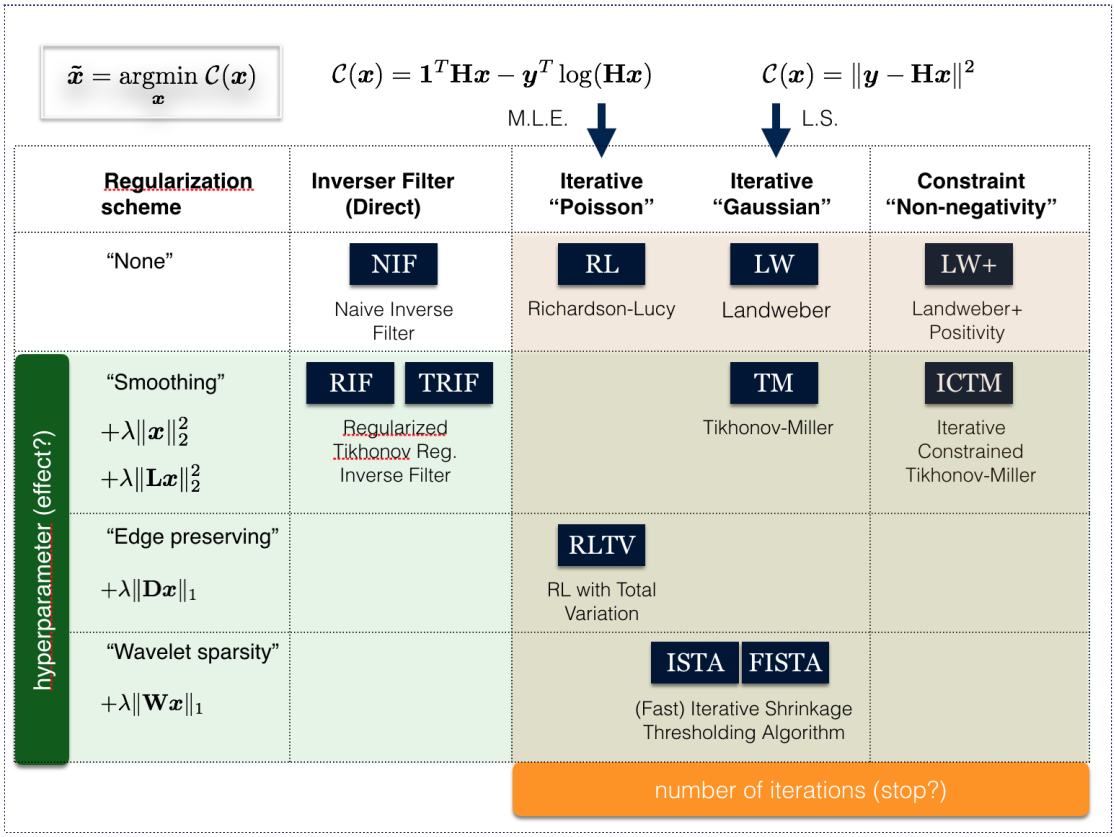
Run	Run the deconvolution task in headless mode
Launch	Start the deconvolution dialog box, then Run the deconvolution task
Batch	The current deconvolution command is added in the Batch table (see Advanced tab)

Algorithms of DeconvolutionLab2

Algorithms	Shortname	Iterative	Step Controllable	Regularization	Wavelets
Deconvolution					
Regularized Inverse Filter Laplacian Regularized Inverse Filter	RIF LRIF	Direct	No	Yes	
Tikhonov Regularized Inverse Filter	TRIF	Direct	No	Yes	

Naive Inverse Filter Inverse Filter	NIF IF	Direct	No	Yes	
Richardson-Lucy	RL	Iterative	No	No	
Richardson-Lucy Total Variation	RLTV	Iterative	No	Yes	
Landweber Linear Least Squares	LW LLS	Iterative	Yes	No	
Non-negative Least Squares Landweber+Positivity	NNLS LW+	Iterative	Yes	No	
Bounded-Variable Least Squares Spark-Parker	BVLS SP	Iterative	Yes	No	
Van Cittert	VC	Iterative	Yes	No	
Tikhonov-Miller	TM	Iterative	Yes	Yes	
Iterative Constraint Tikhonov-Miller	ICTM	Iterative	Yes	Yes	
FISTA	FISTA	Iterative	No	Yes	Haar, Spline
ISTA	ISTA	Iterative	No	Yes	Haar, Spline
Simulation					
Simulation	SIM	Direct	Convolution with a PSF and corruption with Gaussian and Poisson noise		
Convolution	CONV	Direct	Convolution with a PSF (no additive noise)		
Identity	I	Direct	Copy the input into the output		
Non-stabilized Division	DIV	Direct	Division by a PSF in the Fourier domain		

Synopsis of the algorithms of DeconvolutionLab2



Results of DeconvolutionLab2

The results of the deconvolution in terms of image reconstruction are the same than our previous version **DeconvolutionLab**. DeconvolutionLab2 improves the usability through friendly user-interface and it run on various imaging platform It offers a larger choice a FFT librairies and different ways to cancel the border artefacts. In addition, it allows a scripting for batch processing.

Scripting DeconvolutionLab2

The command line of DeconvolutionLab2 consists of a series of arguments that allows a full control of the processing. The command line is written in a single line, space is mostly used as separator. The general format of the argument is:

```
-keyword [option] parameters
```

The list of keywords and the options presenting in the following table. The sign | indicate a OR). The default value are written in bold

Keyword	Default	Options	Description
-image file	Mandatory	Path to a single file (z-stack) usually a TIF or STK file	Source of images. The 3D input data should be a z-stack of images.
-image directory		Path to a directory containing 2D images [pattern	
-image synthetic		Name and parameters of the shape [intensity, size, center]>	
-image platform		Name of the image of the platform (ImageJ or Icy)	
-psf file	Mandatory	Path to a single file (z-stack) used as PSF usually a TIF or STK file	Source of PSF. The 3D PSF data should be a z-stack of images.
-psf directory		Path to a directory containing 2D images [pattern]	
-psf synthetic		Name and parameters of the shape [intensity, size, center]	
-psf platform		Name of the image of the platform (ImageJ or Icy)	
-algorithm	Mandatory	RIF | TRIF | NIF | LW | NNLS | BVLS | RL | RLTV | TM | ICTM | ISTA | FISTA | VC | I | CONV | SIM | DIV Synonym of the acronym: RIF = LRIF, NIF = IF, LW = LLS, NNLS = LW+, BVLS = SP, I = ID	Name and parameter of the algorithm
-path	current	current | path	Working directory
Output (several instances of out are possible)			
-display	yes	yes | no	The final results is displayed
-out stack	intact float	Name of the output: Note that this name is used as title of the window image and as the filename for the storage Option for dynamic: intact | rescaled | normalized | clipped Option for type: byte | short | float Mode: By default the output is shown and saved. nosave | noshow	Output as a stack of images (TIF)
-out series	intact float		Output as series of 2D images (slices, XY)
-out mip	intact float		Output as a maximum-intensity projection
-out ortho	intact float		Output as a 3 orthogonal views centered around the keypoint
-out planar	intact float		Outputs as a 2D side-to-side image of all the z-slices
Controller			
-monitor	console table	console | table | no	Selection of the monitoring output
-verbose	log	log | quiet | prolix | mute	Message monitoring
-stats	show	show | save | no	Statistics
-constraint	no	no | nonnegativity | clipped	Spatial constraint on the signal
-residu	no	no | value	Stops when the minimal residu is reached
-time	no	no | value	Limitation of running time
-reference	no	no | filename	Assess the current deconvolved image with the reference image
Preprocessing			
-pad	NO NO 0 0	NO | X2 | X23 | X235 | E2	Lateral and axial padding and extension scheme

-apo	NO NO	UNIFORM | NO | HAMMING | HANN | COSINE | TUKEY | WELCH	Lateral and axial apodization window function
-norm	1	no | value	Normalization factor for the PSF
Resources			
-fft	fastest	academic | jtransforms | fftw2	Indicates the FFT library
-epsilon	1E-6	value	Machine Epsilon

Example

```
 -image synthetic Cube 10.0 1.0 size 200 100 100 intensity 255.0 -psf synthetic Double-Helix 3.0 30.0 10.0 size 200 100 100 intensity 255.0 -algorithm RIF 0.1000 -out mip MI1 -norm 10.0 -path home
```

Course

Material	Download	Size	Description
Slide in PDF (without the animation/video)	3D-Deconvolution-Microscopy.pdf	4.6 Mb	Course given in Neubias 2020, February 2017
Restoration	**logo.zip**	0.6 Mb	2D simulation, influence of the PSF shape to restore the original image
Naive Inverse Filter	**naive-deconvolution.zip**	3.3 Mb	2D simulation of the inverse filter
Simulation to check the resolution	**test-resolution.ijm**	0 Mb	Macro to generate simulated data and simulated PSF
Simulation to check the spectral effect	**spectral-analysis.zip**	0.7 Mb	2D simulation of fine structures
Hollow bars	**bars.zip**	28 Mb	3D reference, 3D corruputed data and 3D PSF
C-elegans embryo	**c-elegans.zip**	183 Mb	3 fluoresence channels, 3D data and 3D theoretical PSF
Synthetic microtubules	**microtubules-challenge.zip**	63 Mb	3D data and 3D theoretical PSF of a realistic specimen
Drosophila (crop)	**drosophila-crop.zip**	19 Mb	Small 3D data and 3D theoritical PSF
Synthetic microtubules	**real-donut.zip**	463 Mb	3D data and 3D estimated PSF of real well-defined objects (donut)

Conditions of use