

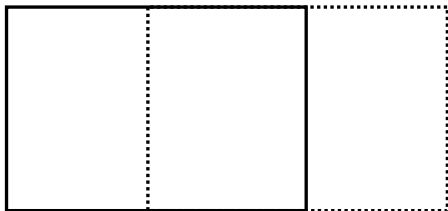
# Distortion Correction Plugin – Manual

This manual describes the usage of the distortion correction plugin for ImageJ. The plugin is open source and also integrated in Fiji ([http://pacific.mpi-cbg.de/wiki/index.php/Main\\_Page](http://pacific.mpi-cbg.de/wiki/index.php/Main_Page)).

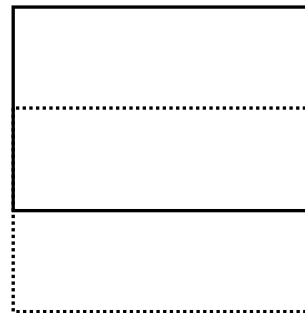
## Preparation: The calibration images

The images used to estimate the lens distortions do not need to be taken from a special calibration probe. The only requirement is that they contain enough contrast and structure spread over the whole image range to ensure enough correspondences between overlapping areas. Correspondences are automatically obtained via SIFT Features.

I propose to just take the specimen you want to image anyway, and take 9 images in a 3x3 matrix. The images should be placed in a way that you have a horizontal and a vertical overlap of about 50%:



Horizontal overlap should be about 50%



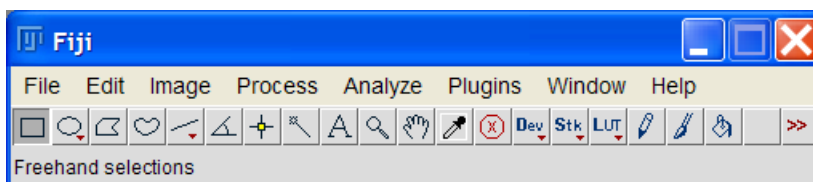
Vertical overlap should also be about 50%

So just take one column of 3 pictures, each overlapping horizontally about 50% with its predecessor. Then shift about 50% of the image width to the right and take the next column, shift again and take the third. This way you end up with a 3x3 matrix that should be good for calibration.

## Using the Plugin

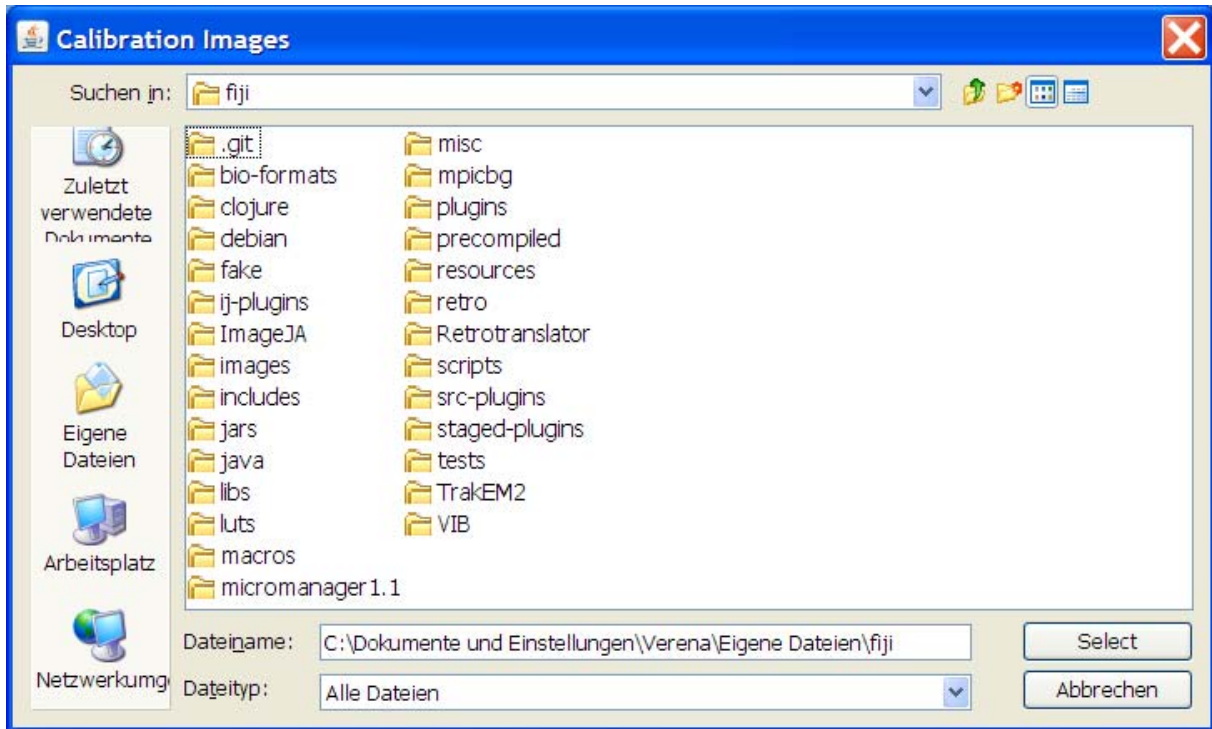
The simplest method is to just put the calibration images into one folder and use the Plugin, save the result and later apply the correction to all images you want. I will assume this setup for now. For more options you can have a look at the Tips section.

So know where your images are and start Fiji:



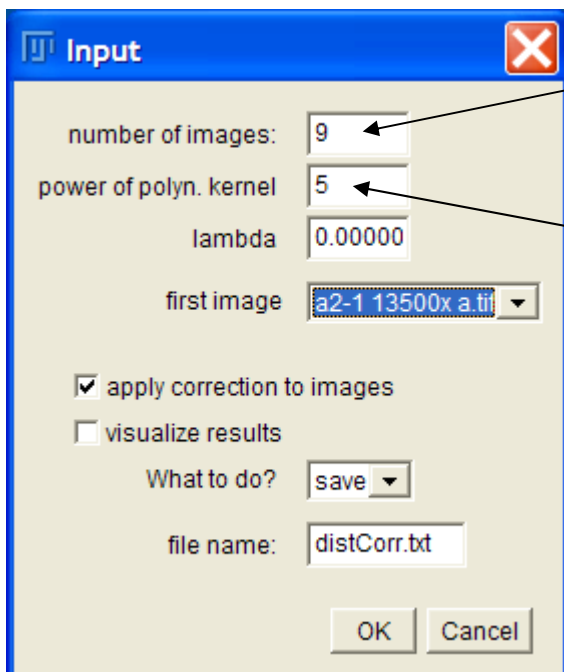
You can find the Plugin under Plugins – Transform – Distortion Correction.

When you start the plugin the first dialog asks you for the directory with the calibration images.



Navigate into the folder where the images are and click Select.

The next step opens an input dialog to adjust your settings.



Number of images that should be used for the calibration. If you followed the 3x3 instructions this should be 9.

Power of the polynomial kernel used to expand the coordinates for the nonlinear transformation. Larger value means more degrees of freedom for the transformation, but so far I did not encounter a case where 5 was not sufficient.

**Input**

number of images: 9

power of polyn. kernel: 5

lambda: 0.00000

first image: a2-1 13500x a.tif

apply correction to images

visualize results

What to do?: save

file name: distCorr.txt

OK Cancel

Lambda determines how much the distortion estimation will be regularized. This is just an initial value. Later on there will be an interactive dialog to adjust this value, if necessary.

Choose the first image in the drop down list that should be used for the calibration. If only the calibration images are in the folder you choose in the step before, the default value should be fine.

**Input**

number of images: 9

power of polyn. kernel: 5

lambda: 0.00000

first image: a2-1 13500x a.tif

apply correction to images

visualize results

What to do?: save

file name: distCorr.txt

OK Cancel

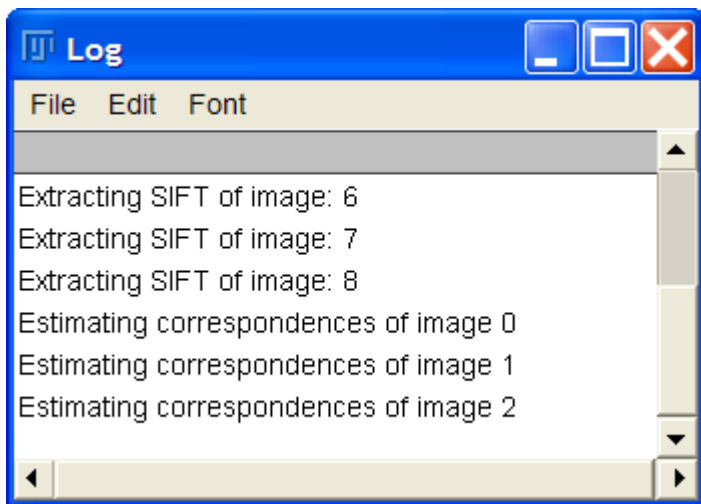
Should the correction be applied to the images in the folder? If this option is checked, the estimated correction is applied to all images in the folder and the corrected images are written into a new folder that the plugin asks for in a later step.

Do you want to visualize the results? This option produces graphic plots of the estimated transformation and the gain in image similarity by using the correction. This option needs a lot of RAM. If you get an out of memory message it is most likely due to this option. Try to uncheck it and run again.

Save or load a transformation file with the name given below.

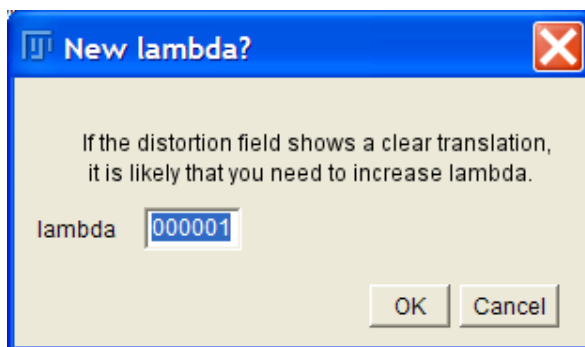
Now the SIFT parameter dialog opens. I suggest leaving the default values as they are and setting the scale to 100%. You also should have a look at the maximum image size, if your images are larger than the value given; the parameter has to be adjusted accordingly. If you want to know what the other parameters are, Albert Cardona wrote a nice description of the dialog, see [http://www.ini.uzh.ch/~acardona/howto.html#sift\\_parameters](http://www.ini.uzh.ch/~acardona/howto.html#sift_parameters).

In the next step correspondence points between the images are automatically found by SIFT feature extraction. A Log window will give you feedback, how far the calculations proceeded.



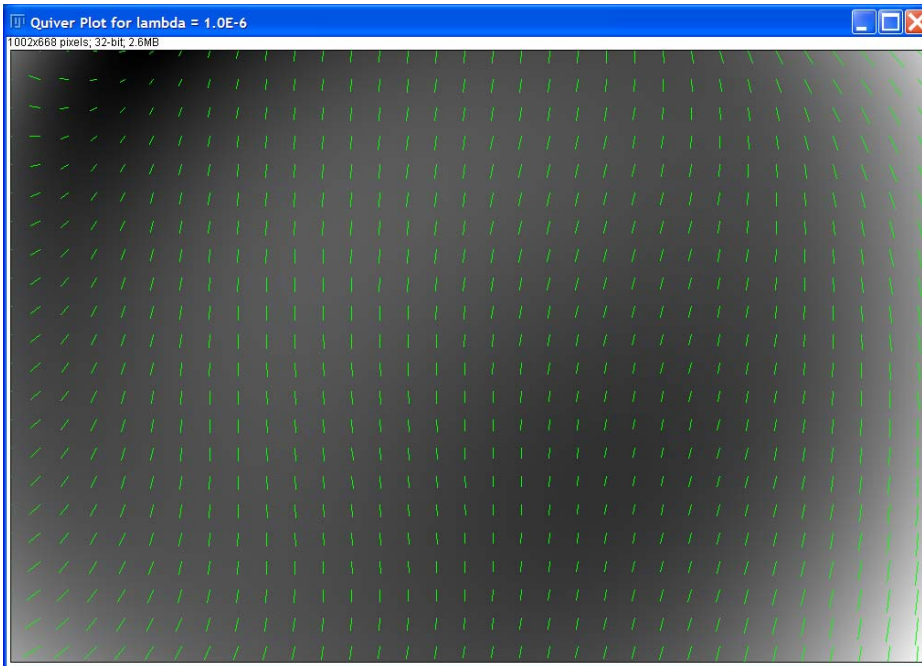
It depends a lot on your computer and the image size, how long this takes. But most probably this is a good time to get a coffee / tea.

When the estimation is finished, you are given the opportunity to adjust the regularization parameter lambda, if necessary:



Pressing the OK button will estimate the distortion again using the new given value for lambda. Recomputation will be much faster than the initial estimation as the correspondences are already found. If you are satisfied with the result press Cancel to proceed with the last value given for lambda. See the next page for criteria whether you should increase lambda or not.

So when is a correction of the lambda value necessary? Here you see an example where lambda should be increased:



If the estimated distortion looks like this, a translation into the same direction is clearly visible in all lines. This is a strong hint, that lambda needs to be increased.

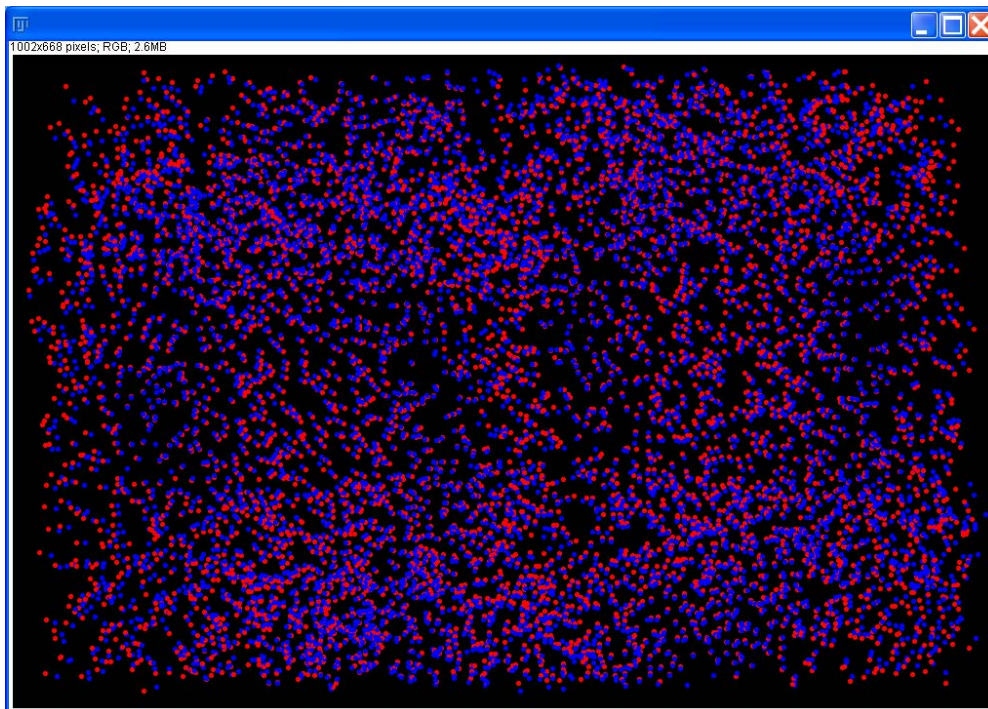


Here you can see the result, if lambda is increased by a factor of 100 (lambda=0.001). It is clearly visible, that the distortion is bigger at image borders and smaller in the middle.

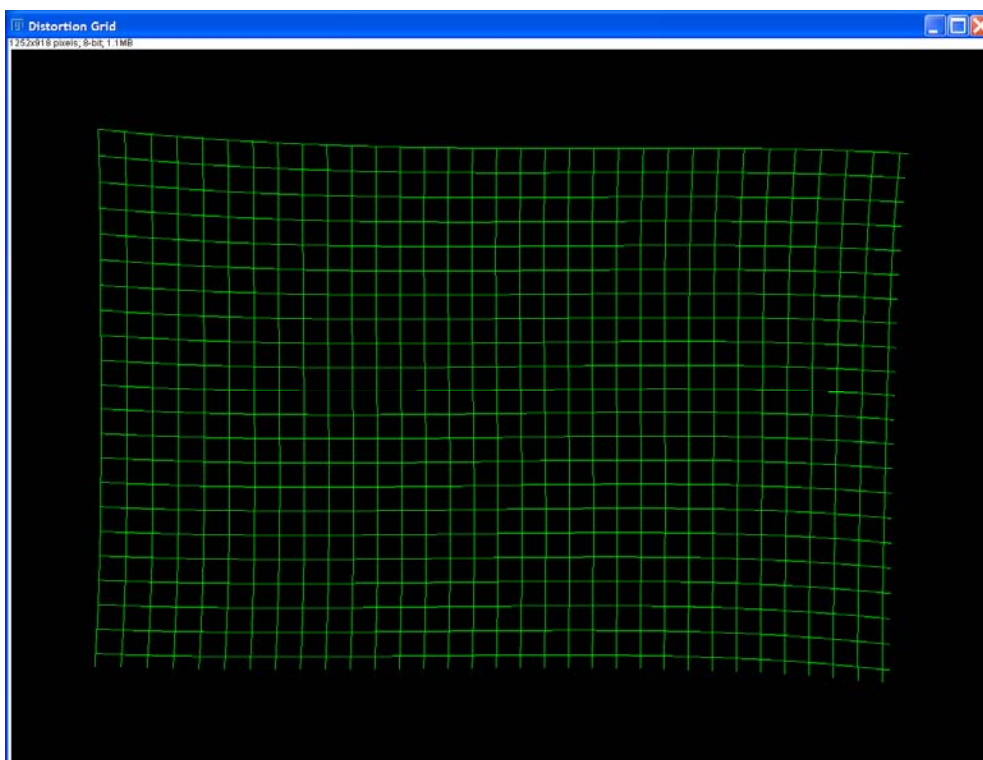
If you checked the “apply correction to images” earlier, then the plugin will now ask you for a target folder for the corrected images. As in the beginning, just specify the folder the images should be saved to.

If you checked the “visualize results” option earlier, a couple of output windows will be produced, showing the results of the distortion estimation.

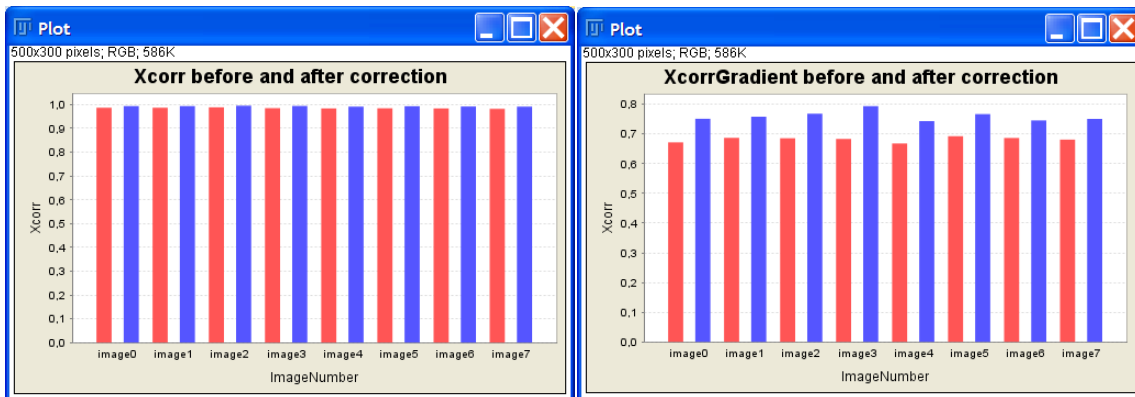
The single windows show the following things:



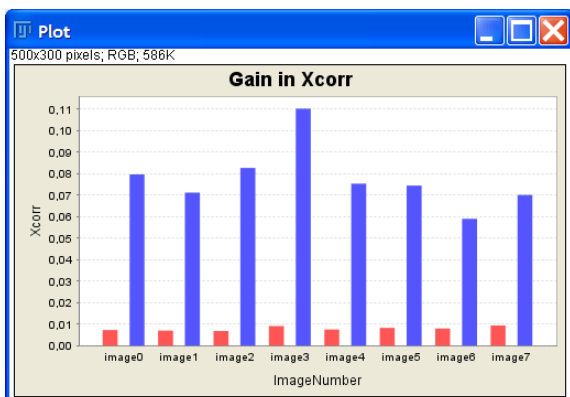
The correspondence points found in the single images all projected into the same coordinate system. The points should cover the whole image area as densely as possible. If no distortions are present only blue points should be visible as the red ones are hidden behind them (perfect match).



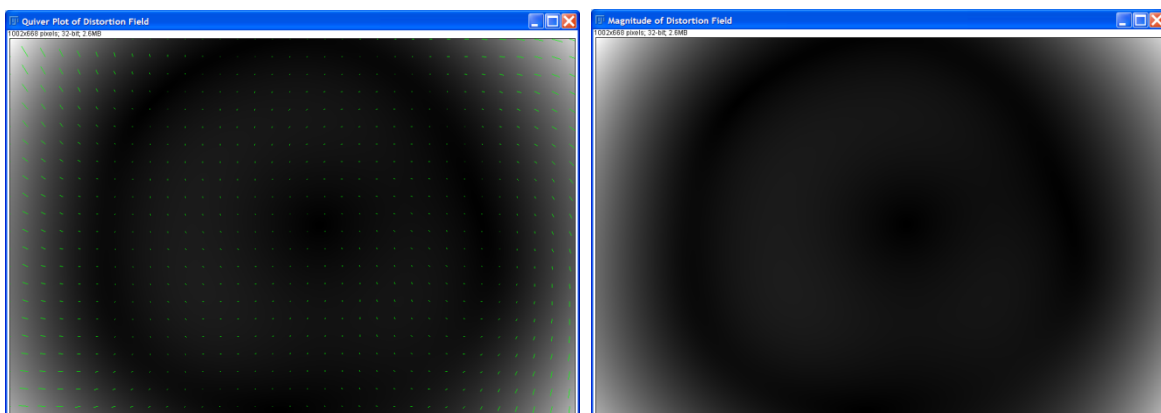
A grid transformed according to the estimated distortion. This is useful to see which kind of deformation is present in the image.



Crosscorrelation of the overlapping areas of the calibration images before (red) and after (blue) the correction is applied. The gradient is shown because it concentrates on edges in the image and these are the image element most people want to match, e.g. for later stitching.



Extra plot to clarify the actual gain in crosscorrelation (red) and crosscorrelation of the gradient images (blue). This is nothing more than the differences between the red and blue bars in the former plots put into their own plot to make them better visible.



Another visualization of the non linear transform. The right image shows only the magnitude of the transformation vectors. The brighter the pixels, the larger the transformation of these areas. On the left the quiver plot of the transformation is plotted on top of the magnitude image.

You now should have a txt-file in the source folder; with the name you specified in the options dialog (default is distCorr.txt). This file contains the transformation parameters and you can load it to apply the estimated correction to as many images as you like. Just put all the images to be corrected and the transformation file into one folder, start the plugin again and choose load instead of save at the options dialog. For the sake of time saving you should also disable the “visualize results” option. The plugin will now just ask for the folder to save the corrected files in and apply the transformation saved in the file to all files in the folder specified.

If you have further questions or suggestions for the plugin, please contact me at [verena.kaynig@inf.ethz.ch](mailto:verena.kaynig@inf.ethz.ch).

## Tips

- Put all images that need to be corrected, including the calibration images into one folder and do distortion estimation and correction in one go:
  - In the options dialog you can specify how many of the images in the folder are used for the calibration.
  - Then choose the first calibration image in the drop down menu (they are required to be named in such a way that no other image squeezed into the alphabetical order of the calibration images.)
  - Do not forget to check the “apply correction” option.
- If you got an out of memory error, it is most likely due to the result visualization option. You can uncheck the option and try again.
- Most of the computation time is spend to find correspondence points between the images. If you specify a scale less than 100% in the SIFT parameter dialog, this will most likely speed up the whole process very much. However, you need to be careful to still have enough correspondence points (you can see this in the points plot if you choose to visualize the results). In addition accuracy of the correction will become worse the smaller the SIFT scale is chosen.