USER'S GUIDE

ImageS

Rel. 2.5

Introduction

Digital image processing is an area aiming to solve problems by the application of computational algorithms to digital images. The processing result can be either images or a set of representative characteristics or properties of the original image.

Digital image processing is used for two different purposes: a) improving the visual appearance to human viewer and, b) preparing image to measure, recognize or remove features or structures. For visual enhancement, this means having some familiarity with the human visual process and an appreciation of what cues the view responds to in images. On the other hand, the measurement of image can be performed on entire scenes or on individual features and is used for acquiring scientific data or industrial applications. The measurements are determined by the application. Size, shape, direction, position and area are common measurements in image processing. For measuring a prerequisite is the separation of objects or features within the image. This processing is known as segmentation which consist of separating the image into regions that are homogeneous or similar (Russ, 1998, Moya 2012). Image segmentation is one of the most difficult tasks of image analysis and the accuracy of measurement depends on the result of it.

Segmentation

Segmentation is a very important issue in digital image processing. A variety of algorithms have been developed trying to find optimal solutions for specific applications. The goal of segmentation is to split the image into sets with homogeneous features. Segmentation fall into three block:

- Image-based level. It has only information given by the pixels.
- Surface-based level. It is required to incorporate contextual information not included directly in the image.
- Object-based level. It is a high-level category which requires prior information objects.
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Segmentation can be unsupervised and supervised. In the first, the segmentation is performed only with information provided by image (fully-automatic), in the second is based on information given by

user (semi-automatic), e.g. a criterion to determine the background and foreground.

To formally define the task of segmentation is required a detailed notation of the image as set, as well as some definitions. Following the same notation, an image I is non-empty set of pixel. A region R is a non-empty subset of the image I such that $R \subseteq I$, $R \neq 0$. The region is not required to be topologically connected. However, some methods may have the restriction that the region should be connected. A partition P of an image I is a set of n regions $\{R_i = 1, \dots, n\}$¡ Error! Marcador no definido. such that $\cup_{i=1}^{n} R_i = 1$ and $R_i \cap R_j = 0$ for $i \neq j$ So, the segmentation S is a partition P of the image I that satisfies for each region $R_i \in S, i = 1, \dots, n_{opt}$ where n_{opt} is the optimal number of regions that avoid over-segmentation. An image is over-segmented if the regions found are more than needed$n > n_{opt}$, on the other hand, the sub-segmentation occurs when regions are less than optimal (Moya, 2012, Lukac and Plataniotis, 2006)

ImageS software is a powerful tool to performance image segmentation. ImageS include preprocessing, segmentation and morphological operation tools. Developed software have four robust algorithm for color and gray image segmenting, those are: E-CQMMF, Active contour, Fuzzy EMGMM and GMMM.

INSTALLATION

ImageS software was developed over MATLAB platform, for this reason, it is necessary to install MCRinstaller.exe. It should be mentioned that the software is only available for windows 64bits. MCRistaller.exe can be downloaded from MATLAB page web or install it from package ImageS which includes MCRinstaller.exe. For installation follow the next steps.

FILE

ImageS works with color, gray and binary images. The first step is load image. Options for loading images are:

1. Open color image. Processing and segmentation tabs will be activated.

2. Open binary image. You only can work with editing tab.
3. Color and binary image. This mode works with both images in joint. And all tabs will be activated.

The next options (save) from file tab will be activated when you start to proceed the image.

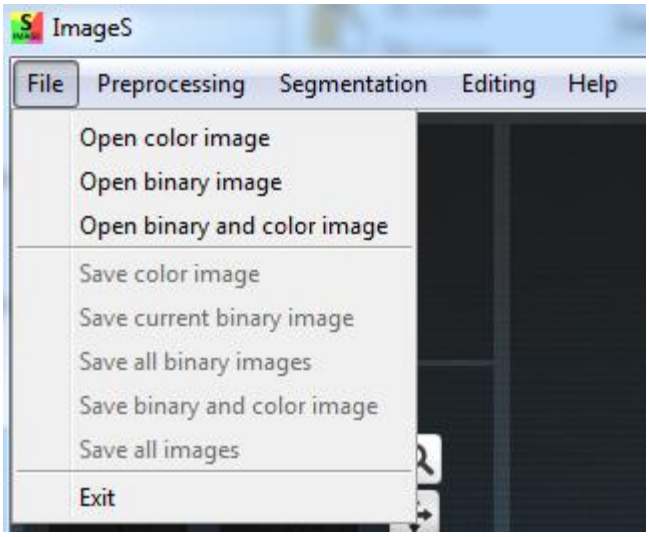

Figure 1. File tab.

Preprocessing

Before of start to segment image, it is recommendable preprocess it. The options are shows in figure 2:

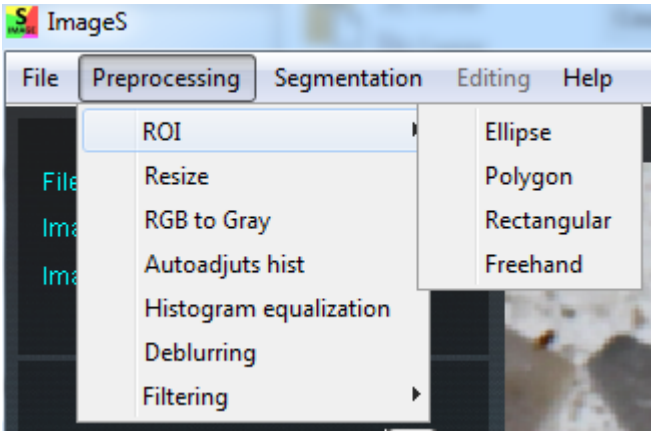

Figure 2. Preprocessing tab.

You can choose a ***region of interest*** from the images. When you select one of the four options, a new figure opens. Once the figure is open,

begin to draw the area of interest. It is important to note that once the region is closed it is necessary to double click to validate it. If the selection process was correct, then the figure is closed and the selected area is displayed on the main axes.

It is advisable to use ***resize tool*** when the images are large and present redundant information. The figure 3 shows an example. You can choose new size using scroll or write it directly.

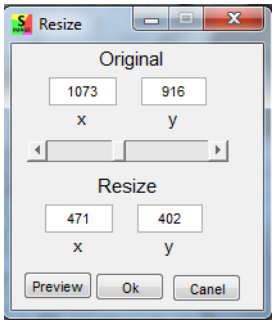

Figure 3. Resize tool.

The ***rgb to gray, auto adjust and equalization*** tools are directly applied to the image, this tools do not need tuning.

Sometimes the images are out of focus, so we have incorporated a ***deblurring tool***. In figure 4, the parameters of this tool are shown. Length parameter correspond to linear motion at angle theta. The Noise is a factor from 0 to 1 and correspond to Noise to Signal Ratio.

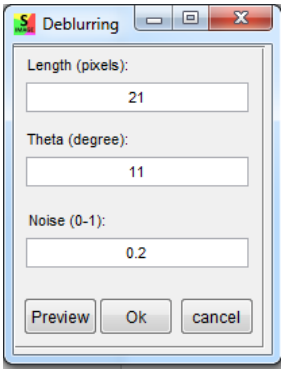

Figure 4. Deblurring tool

In the tab filtering, there are two kind of filter, lineal and non-lineal. The ***filter lineal*** are so-well known and recommend you review any image processing book. For ***non-linear filters*** we give an overview

of their use. ***Nonlinear Beltrami filter*** is based on the Beltrami flow which is an efficient noise reduction method based on a geometric diffusion flow approach. The noise reduction method based on the Beltrami flow has no complicated parameters to be tuned, as the detection of the edges and estimation of their strength is performed based on derivatives. This method is resolved in an iterative way and this parameter should be defined by inspection subjective. The other parameter is time step. The maximum value for time step parameter, for stability, should be the inverse of the squared number of dimensions (Fernández and Martínez, 2010). Figure 5 shows the filter wizard Beltrami. The other nonlinear filter, ***Kuwahara filter***, is based on variance. Kuwahara filter works on a divided window into 4 overlapping subwindows. In each subwindow, the mean and variance are computed. The output value (located at the center of the window) is set to the mean of the subwindow with the smallest variance. For this reason the window size should be 4*k+1, where k is an integer greater than zero(Bakker et al., 1999).

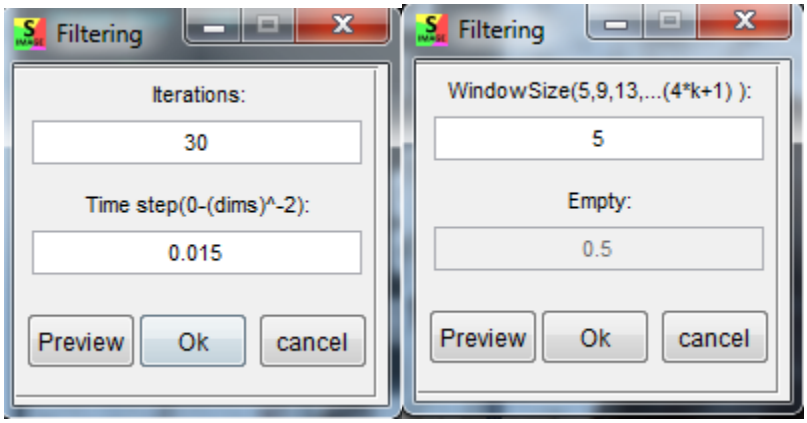

Figure 5. Nonlinear filters wizards. Left: the Beltrami filter wizard. Right: the filter Kuwahara.

SEGMENTATION

In the segmentation tab are found four segmentation algorithms which have been chosen because they are the best algorithms according to our experience.

E-CQMMF (Entropy-Controlled Quadratic Markov Measure Field) algorithm was developed by Mariano Rivera and collaborators (Rivera et al., 2007). This model is based on Markov Random Measure, low entropy and optimization iterative. Model can be work with any likelihood function. ImageS software used a Gaussian likelihood function. E-CQMMF have three parameters tuned by user: λ hyperparameter that control the granularity of segmentation, typical value is 0.5, μ control the entropy, typical value is 0.5, and, number of iteration.

E-CQMMF as well as ***Fuzzy GMM*** and ***GMM*** works in two mode. The first mode multiple labels, this mode is useful when you want to segment in more than two regions. The second mode allows segmenting only in two regions. Figure 6 shows an example of type segmentation.

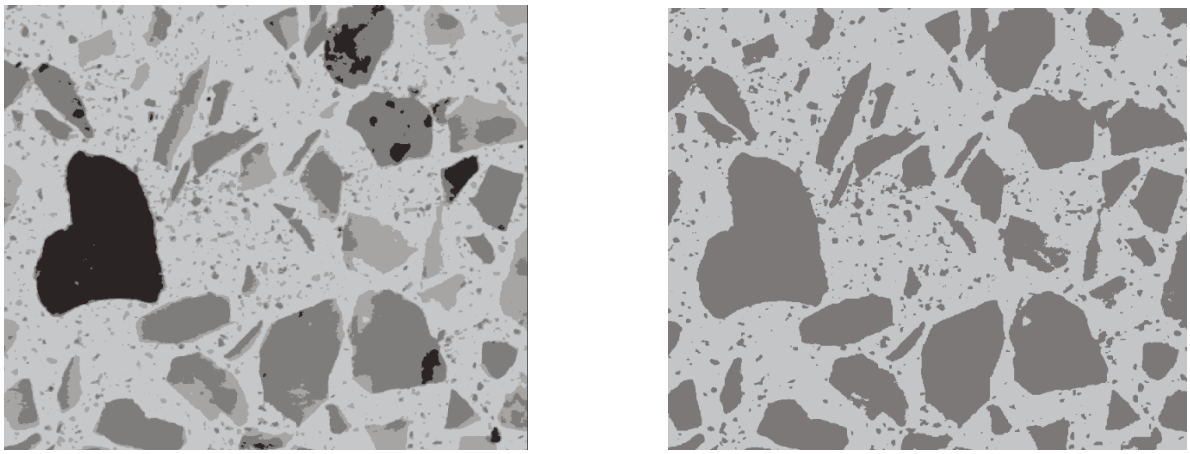

Figure 6. Segmentation modes. Left: the multiples labels and right: two label (foreground and background).

Steps to follow to segment in ***multiple labels mode***:

1. Load image and if it is necessary to apply preprocessing.
2. Choose the E-CQMMF, FGMM or GMM segmentation algorithm in segmentation tab.
3. Select in wizard the n-models mode.
4. Press the pattern selection button and draw the area that represents this pattern model. Remember! When you finish selecting the area double click on the drawn line to finish the selection, if the selection has been the correct the color of the line must change
5. Press the select pattern button again to select another model.
6. Continue selecting the areas until obtaining number of models desired.
7. Once the desired models have been selected, adjust the parameters and then press the segment button.
8. At the end of the segmentation press the ok or cancel button.

Steps to follow to segment in ***two labels mode***:

1. Load image and if it is necessary to apply preprocessing.
2. Choose the E-CQMMF, FGMM or GMM segmentation algorithm in segmentation tab.

3. Select in wizard the two-models mode.
4. Press the select foreground pattern button and draw the area that represents this pattern model. Remember! When you finish selecting the area double click on the drawn line to finish the selection, if the selection has been the correct the color of the line must change
5. Press the select foreground pattern button again to select another area that represent foreground model.
6. Continue selecting the areas until obtaining number of areas that represent the foreground model.
7. Repeat the steps from 4 to 6 but for background pattern.
8. Once the desired models have been selected, adjust the parameters and then press the segment button.
9. At the end of the segmentation press the ok or cancel button.

FGMM and GMM algorithms segmentation are very similar. ***Gaussian Mixture Model*** is a type of clustering algorithm. It is assumed that histogram of image is a Gaussian Mixture Models each is an independent distribution with their own mean and covariance matrix. The mean and covariance matrix of each model is optimized using an iterative technique called Expectation Maximization. We have modified this algorithm by spatial coherence filter. This filter reassign the probability of a pixel according to neighborhood. This fact smoothing the segmentation and some cases improving it, see Figure 7.

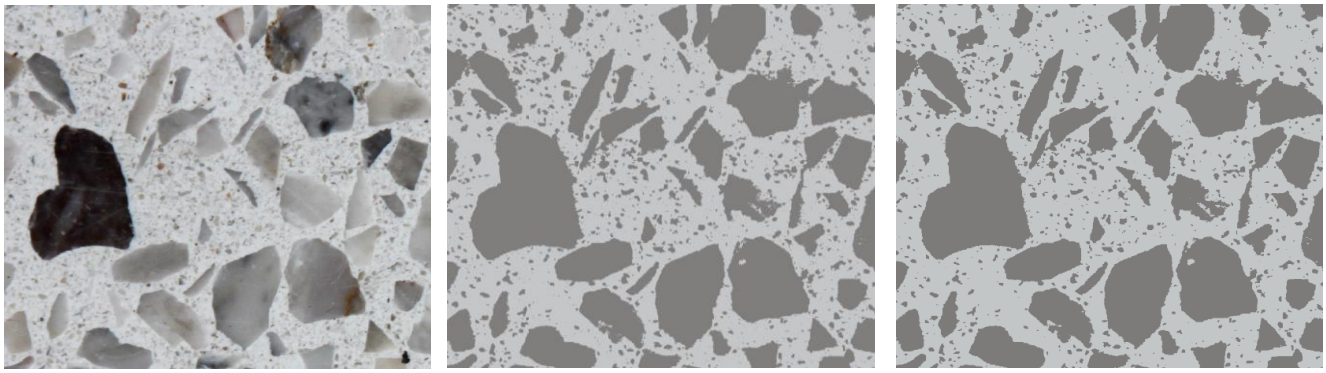

Figure 7. Left: original image. Center: segmented image without spatial filter. Rigth: segmented image using spatial filter of 8 pixel size.

GMM algorithm segmentation have two parameters to tune, iteration and size of spatial coherence filter, the typical values are 10 and 6, respectively.

FGMM algorithm has the same base as the GMM, however in the FGMM, all pixels have a degree of belonging to each model, and so the mean and variance are estimated using all pixels and their degree of belonging. FGMM improves segmentation and converges faster than GMM algorithm. The only parameter to adjust is the number of iterations whose typical value is 20.

Active contour is an algorithm developed by us but based on (Chan and Vese, 2001). Active contour is a technique of curve evolution which detect object's borders. Active contour minimize an energy from viewpoint of minimal partition problem and not by gradient of image. Numerical Algorithm uses finite differences. This algorithm need initial curves and tuning three parameter; iterations, and internal and external factor. Number of iteration depend of size and number of initial curves. The larger the image and the smaller the number of initial regions the number of iterations should be larger and on the contrary the smaller the image size and the greater the number of initial regions the smaller the number of iterations. The internal and external parameters can be seen as strength of the curve in and out.

Steps to segment using active contour:

1. Load image and if it is necessary to apply preprocessing.
2. Choose Active contours algorithm in segmentation tab.
3. Press the select button and draw the initial curves. Draw is freehand. Remember! When you finish selecting the area double click on the drawn line to finish the selection, if the selection has been the correct the color of the line must change
4. Tune the parameters.
5. Select o deselect live display, and press segment button to performance the segmentation.
6. At the end of the segmentation press the ok or cancel button.

Figure 7 shows an example of results obtained at different internal and external values.

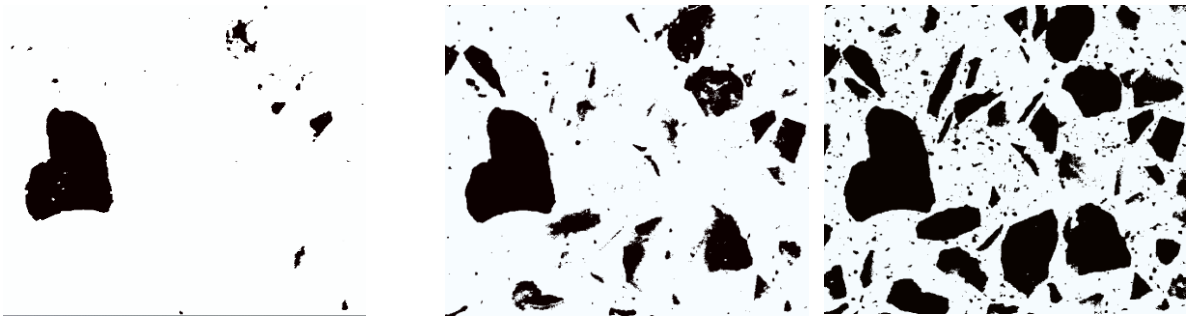

Figure 7. Segmented image using internal and external value. Left: internal=0.5 and external=0.1. Center: internal =0.5 and external=0.5. Right: internal=0.1 and external=0.5.

EDITING

Although the segmentation algorithms are robust, sometimes the segmentation needs to be edited. For this reason, we incorporate binary image ***editing tools***. The editing tab consists of the tools; Morphological operations, split operation, manual editing and logical operations.

Morphological operations tool consist of 19 operations, we recommend you review this operation in (Gonzalez, 2009).

Steps to apply using morphological operations:

1. Load the image and if it is necessary to apply preprocessing and segmented it.
2. The clean operation is loaded by default. To add more operations, go to the operation menu, add the desired operation and the number of times to apply and then press the add button. It can preview the result, press preview button.
3. If you want to remove smaller and larger areas at a certain area threshold (in pixels), go to the area threshold section and adjust.
4. Finally, it choose if the operations will apply to all images or only current image, and after press ok or cancel button

Split operation tool separates binary objects that are touched slightly. This tool performs separation based on watershed segmentation and erosion and dilating operations. Figure 8 shows an exmple.

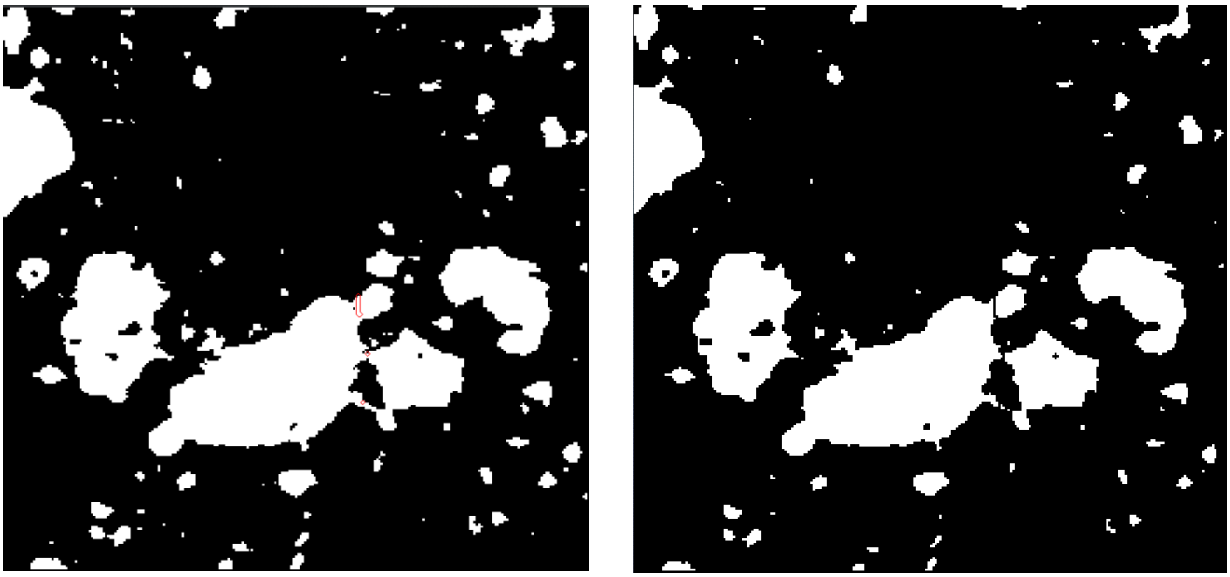

Figure 8. Left: image with objects touched slightly which is highlighted in red. Right: the image with cut objects..

Manual editing tool allows you to remove or add areas drawn by the user.

Steps to remove or add areas:

1. Load the image and if it is necessary to apply preprocessing and segmented it.
2. Go to edit tab and select manual editing.
3. In the wizard the options to add or remove appear, select the desired action, then press the paint button. Now you can draw freehand areas to add or remove. To end the action press the escape key.
4. Once the editing is finished press the ok or cancel button.

Logical operations tool allows you to apply the most common logic operations between two or more images.

Steps to apply logical operations:

1. Load the image and if it is necessary to apply preprocessing and segmented it.
2. Go to edit tab and select logical operations.
3. The wizard have two blocks: masks and operation. In the mask block the images resulting from the segmentation are displayed and in the operations block the operations to be performed are shown. It must select an image and press the add button after choosing a logical operation and again an image with which to perform the operation.

4. It can preview the result by pressing the preview button.
5. Once the result is satisfactory press the ok button or otherwise cancel.

Figure 9 and 10 illustrates how to use morphological operations

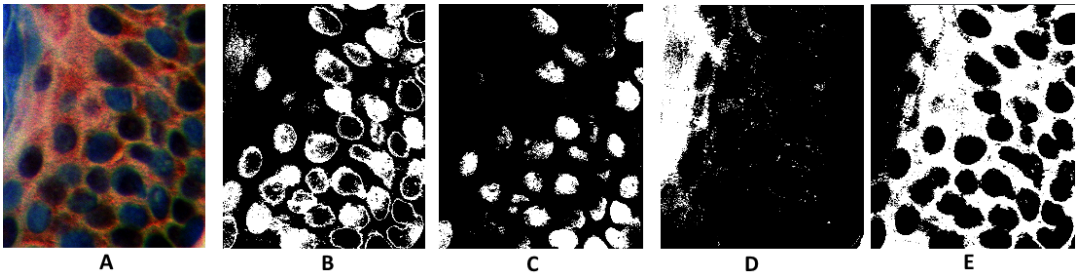

Figure 9. In A is show original image and from B to E are show mask result of FGMM segmentation using four pattern in multiple mode.

If it want to join the images of Figure 9 B and C, it need to apply the logical OR operation. The result is show in figure 10.

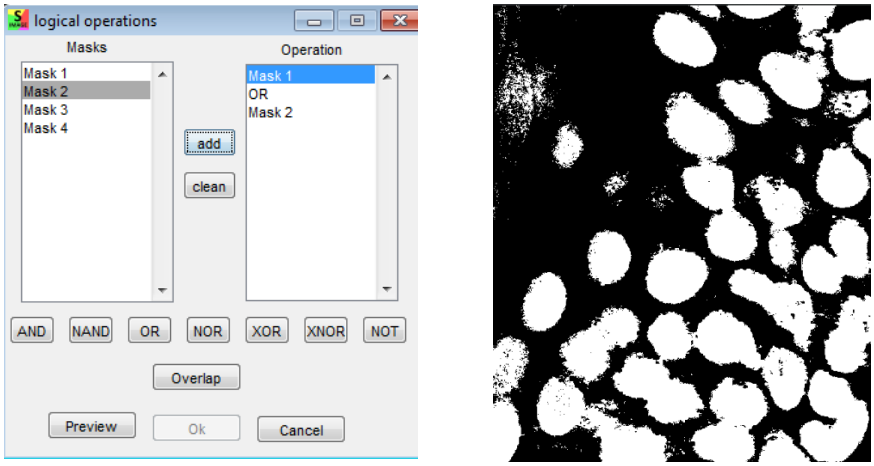

Figure 10. Left: Procedure in the wizard to apply morphological operation OR. Right: resulting image.

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