

# Watershed segmentation: Switching back and forth between markers and hierarchies

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## 1. Introduction

The watershed transform [2] is a robust approach applied to digital image segmentation, once the watershed lines produced are very close to the object boundaries. However, there is a common problem of oversegmentation of the image. In order to avoid this situation, the watershed transform can be applied from a set of markers, in place of the local minima of the image. This approach, known as *watershed from markers* [2], reduces the segmentation problem to the problem of finding a proper set of markers for the objects and for the background of the image to be segmented.

For this reason, the watershed from markers is a suitable approach for interaction: handling the set of markers interactively, the user can manage the segmentation process. In this manner, one is able to achieve the desired segmentation in a faster way, without needing to configure a lot of parameters or specifying formally a method to obtain an adequate set of markers in an automatic way.

We first present an interactive tool for image segmentation [1] based on the *watershed from markers*. The user interaction focuses on the manual edition of the set of markers used by the algorithm.

In the sequel, we describe interactivity in the context of the *hierarchical watershed* and current investigations that aim to merge both approaches in order to reduce the interaction effort.

## 2. The segmentation tool

The graphical interface of the developed tool consists of an editor used to manipulate the set of markers. The basic tool available is the *brush/eraser*, shown in Figure 1(a). With the *brush/eraser*, the user can draw markers and, without having to select another tool, erase the markers, just using different mouse buttons. If it is necessary to draw different markers that overlap, the user can select one color for each marker, resulting in a different catchment basin for each marker. The user can select an already used color using the *Color selector*, shown in Figure 1(b).

Another characteristic of the tool is the option *Segment automatically*, enabled by default, that executes the watershed algorithm after each edition of the markers, enabling the user to quickly find the adequate set of markers. If this option is disabled, the user can perform an execution of the algorithm by clicking the *Segment* tool in the toolbox, shown in Figure 1(c).

The tool allows the user to choose if the watershed algorithm will be applied over the original image or over the morphological gradient, which is the default behavior (this can be changed in the *Options* menu).

To facilitate the edition of the markers, in the *Layers* panel, shown in Figure 1(e), the user can control the visibility of the images involved, that are superimposed in five layers: the watershed lines, the set of markers, the filtered image, the original image and a blank background. The resulting output image is composed considering the visibility of these layers. Moreover, the user can save a file containing only the set of markers, making possible posterior refinements to the segmentation.

To allow the user to make small markers, in order to precisely segment detailed regions, it is also available a *Zoom-in/Zoom-out* tool, shown in Figure 1(d).

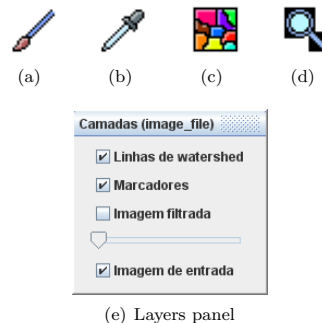


Figure 1. Some of the tools available: (a) Brush/Eraser (b) Color selector (c) Segment (d) Zoom (e) Layers panel

## 3. Hierarchical watershed

Although the *watershed from markers* is a segmentation approach suitable for user interaction, in order

to achieve a precise segmentation, considerable interaction effort (marker redesign) may be necessary.

### 3.1 Interactivity using hierarchical watershed

The *hierarchical watershed* generates a set of images segmented in different levels of resolution [4], from which one can choose the level of segmentation of each region of interest. This choice is made through various cuts on the hierarchical structure, that generally has a large vertex set, once it is proportional to the number of local minima of the image.

To achieve this goal, a suitable approach is to manipulate the hierarchical structure through the following operations, illustrated in Figure 2, as proposed in [3]:

- choice of the number of regions (Figure 2(a)): this can be done through a slider control used to select a determined level to cut the entire hierarchical structure;
- split a region (Figure 2(b)): the user selects the desired region to be re-segmented directly in the image and a cut is done in a lower level than the current level of the region on the hierarchical structure;
- merge regions (Figure 2(c)): as in the previous operation, the user selects directly the region to be merged and a cut is done in a higher level than the current level of the region on the hierarchical structure, merging it with some of its neighbouring regions, according to the hierarchy.

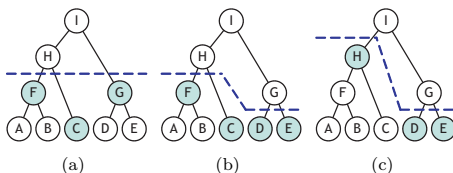


Figure 2. Operations over the hierarchical structure: (a) 3 regions (F, C and G) selected by a single cut. (b) Region G splitted in D and E. (c) Regions F and C merged in H.

Notice that these operations can be done in user real time, once the hierarchical structure have to be constructed only once.

### 3.2 Hierarchical watershed and watershed from markers

Currently, we are investigating the relation between markers and the hierarchical watershed as a method to reduce the interaction effort to achieve a satisfactory segmentation result. More specifically, we would like to:

- given an hierarchical structure, with cuts at several levels, obtained after a sequence of the operations described in Subsection 3.1, generate a set of markers that, used in the watershed from markers algorithm, results in the same partition of the image;
- given a set of markers and the corresponding partition of the image, do appropriate cuts at the structure of the hierarchical watershed in order to obtain the same segmentation result.

## 4. Conclusions

With functionalities like the ones described in Subsection 3.2, the user can be benefited by alternating between the two approaches.

For example, a manner to obtain quick results by alternating between the two watershed approaches would be: the user selects a level at the hierarchical structure, using a slider control to find a partition that most approximates to the desired result; then, switching to the markers approach, the user handles the automatically generated markers set, refining just the necessary details. In this way, the user doesn't need to create manually the markers for each object of the image, just correcting the regions that weren't segmented as desired by the hierarchical watershed.

## References

- [1] B. Klava, *Ferramenta interativa para segmentação de imagens digitais*, December 2006. Available from: <http://www.ime.usp.br/~klava/tfs/>.
- [2] S. Beucher and F. Meyer, *Mathematical morphology in image processing*. The morphological approach to segmentation: the watershed transformation (E. Dougherty, ed.), M. Dekker, 1993.
- [3] B. Marcotegui, F. Meyer, and F. Zanoguera, *A toolbox for interactive segmentation based on nested partitions*, International Conference on Image Processing **1** (1999), 21–25.
- [4] S. Beucher, *Mathematical Morphology and its Applications to Image Processing*. Watershed, hierarchical segmentation and waterfall algorithm (J. Serra and P. Soille, eds.), Eds. Kluwer Acad. Publ., Dordrecht, 1994.