Watershed Transform based Interactive Image Segmentation Tool

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Abstract

Watershed from markers and hierarchical watershed are approaches suitable for interactive image segmentation: in the former, the user can edit markers to control the segmentation result; in the latter, the user can select an image partition from a nested set of partitions. We propose an interactive image segmentation tool that allows transition from one approach to other and thus the combination of the strengths of both.

1 Introduction

The *watershed from markers* and the *hierarchical watershed* are approaches derived from the watershed transform [2]. In spite of being approaches suitable for interaction, they both have shortcomings: when using markers, a considerable interaction effort is demanded if there are a lot of regions to be marked; when using the hierarchy, borders are necessarily a subset of the borders of the primitive regions and there are partitions that can not be obtained due to the way the hierarchy is built.

Previous works that use both approaches together [4, 6, 8] consider the region adjacency graph (RAG) of an initial fine partition as the underlying structure. Markers drawn on the image are mapped to the RAG vertices and operations are performed on the RAG, determining a partition with region level precision (i.e., all regions are unions of primitive regions). In these works, the computation of markers corresponding to a given partition is not considered.

If one desires to place contours beyond those at the border of the primitive regions, it is important that the watershed from markers operates at a pixel level precision. Moreover, computing the markers corresponding to a given partition may be useful, for instance, to segment a sequence with similar frames in videos.

Therefore, a desirable characteristic in a segmentation tool is the ability to work with hierarchies (region level precision) and with markers at a pixel level precision. In the next section we extend our previous work [5], briefly discussing how to map a partition of a hierarchy to a set of markers that recover the same partition and, conversely, how to map a partition corresponding to a set of markers to a hierarchy of partitions. Then, we describe the interaction possibilities that have been implemented in an interactive image segmentation tool. The tool, written in Java, implements the watershed algorithm by the *image foresting transform* [3]. In Section 3 we present the conclusions.

2 Switching back and forth between the watershed approaches

The transition from the hierarchical to the markers approach is addressed through the *minimal seed set* problem, which consists in finding a minimal set of markers that can be used to obtain a partition P by the watershed [1]. If the markers are computed in the RAG and watershed from markers is applied on the pixels graph, the resulting partition P' may differ from P. However, the set of markers computed in the RAG tend to be compact and located more at the center of each region, whereas those computed on the pixels tend to be located at the borders of the regions. We have a proof that P is also an optimal partition, equivalent in cost to P'. For user edition, markers computed in the RAG are more appropriate.

In the inverse transition, as the primitive regions are atomic units in the hierarchy, if a partition P contains borders that crosses some of them, then P can not be represented in the hierarchy. In this case, a possible approach is to set the same label for all the pixels within each region, for example, the most frequent label among them. Furthermore, it is also necessary that each set of primitive regions with same label (that actually make up a region) is a connected set considering the edges of the spanning tree of the RAG from which the hierarchy is constructed.

Details of these transitions will be included in an extended version of this work. Next, we describe the imple-

mented interaction possibilities that explore the strengths of both approaches.
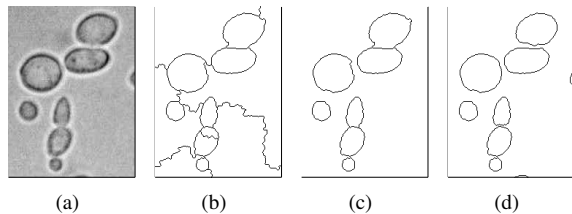

Figure 1. Segmenting using hierarchy and markers: (a) Original image. (b) Partition selected on the hierarchy. (c) Partition after welding regions. (d) Partition with refinements at pixel level precision.

Construction of hierarchies of partitions: by uniform and synchronous floodings, as described in [7], ranking regions by their contrast and/or size. To navigate through the hierarchy, the tool provides a slider control to select a threshold value for the weight of the edges to be suppressed in the RAG. It is also possible to apply local operations (merge and refine) as described in [9].

Merging of adjacent regions with a welding brush: more flexible than the local merge operation over the hierarchy, it can weld regions using edges that are not in a minimum spanning tree of the RAG. This operation was used to obtain the partition of Fig. 1(c), as it cannot be found on the original hierarchies.

Automatic generation of markers: to refine the partition at a pixel level precision, for example, to separate the cells as in Fig. 1(d).

Use of the hierarchy in a selected region: This enables the user to refine (re-segment) a region. For instance, to obtain the primitive regions of the land on a satellite image, one could first design markers by hand in order to separate land from water, then, applying the hierarchy in the land region, select the finest partition, as in Fig. 2.

3 Conclusions

We presented an approach that enables the use of the hierarchical watershed and the watershed from markers interchangeably. Having this possibility in hand, one can take advantage of the best features of each approach, obtaining the desired results with less interaction effort than when using only one of the approaches. The approach has been implemented in an interactive segmentation tool, which will be made publicly available.
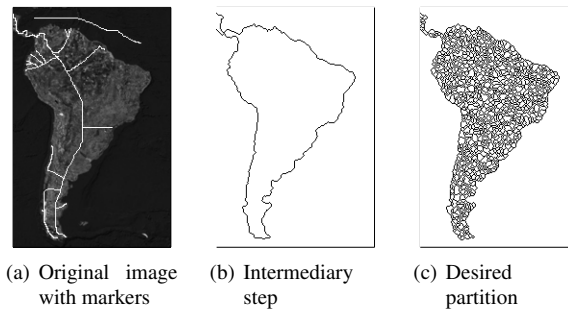
Figure 2. Using hierarchy restricted to a region: (a) Original image. (b) Partition separating land from water. (c) Primitive regions of the land region.

References

[1] R. Audigier and R. Lotufo. Seed-relative segmentation robustness of watershed and fuzzy connectedness approaches. In *Proceedings of SIBGRAPI 2007*, pages 61–70. IEEE Computer Society, 2007.

[2] S. Beucher and F. Meyer. The morphological approach to segmentation: the watershed transformation. In E. Dougherty, editor, *Mathematical morphology in image processing*, chapter 12, pages 433–481. M. Dekker, 1993.

[3] A. X. Falcão, J. Stolfi, and R. de Alencar Lotufo. The image foresting transform: Theory, algorithms, and applications. *IEEE Trans. Pattern Anal. Mach. Intell.*, 26(1):19–29, 2004.

[4] H. K. Hahn and H.-O. Peitgen. IWT - interactive watershed transform: A hierarchical method for efficient interactive and automated segmentation of multidimensional gray-scale images. In *Medical Imaging 2003: Image Processing. Proceedings of the SPIE*, volume 5032, pages 643–653, 2003.

[5] B. Klava and N. S. T. Hirata. Watershed segmentation: Switching back and forth between markers and hierarchies. In *Proceedings of ISMM 2007 - 8th International Symposium on Mathematical Morphology*, volume 2, pages 29–30, October 10–13 2007.

[6] B. Marcotegui and F. Zanoguera. Image editing tools based on multi-scale segmentation. In H. Talbot and R. Beare, editors, *Proceedings of ISMM 2002*, pages 127–135, 2002.

[7] F. Meyer. Hierarchies of partitions and morphological segmentation. In *Proceedings Scale-Space '01*, pages 161–182. Springer-Verlag, 2001.

[8] F. Meyer. An overview of morphological segmentation. *International Journal of Pattern Recognition and Artificial Intelligence*, 15(7):1089–1118, 2001.

[9] F. Zanoguera, B. Marcotegui, and F. Meyer. A toolbox for interactive segmentation based on nested partitions. In *Proceedings of ICIP*, volume 1, pages 21–25, 1999.