FAST IMPLEMENTATION OF WATERFALL BASED ON GRAPHS

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Abstract The waterfall algorithm is a contrast-based hierarchical segmentation approach. In this paper we propose an efficient implementation based on the minimum spanning tree of the neighborhood graph. Furthermore, other hierarchies are proposed and compared to the original version of the algorithm.

Keywords: Hierarchical image segmentation, watershed, waterfall, minimum spanning tree, graphs.

Introduction

Segmentation, together with filtering is often the first step of image analysis or image interpretation. The success of the whole chain of treatment relies on the accuracy of the segmentation results. Important efforts have been devoted to segmentation during the last years and it still remains a key topic of research.

The watershed transformation [3, 1] is the paradigm of segmentation of Mathematical Morphology. It has proved to be a powerful tool used in the solution of multiple applications. Its main drawback is the over-segmentation produced. Two approaches are proposed in the literature to overcome this drawback:

- the selection of markers [9], which supposes that the characteristics of the interesting objects are known;
- hierarchical approaches, that are able to rank the importance of each region.

We focus on hierarchical approaches because of their ability to segment generic images.

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Several hierarchical approaches can be found in the literature. Grimaud [4] introduced the dynamics of minima that assign to each minimum a measure of its contrast. By thresholding this measure with increasing values, a hierarchy is obtained. Najman and Schmitt [10] showed that the same measure of dynamics may be assigned to a contour and introduced the geodesic saliency of watershed contours. Vachier and Meyer [11] generalized the concept of dynamics with the extinction values and proposed to assign to a minimum other measure than contrast such as area or volume. Volume extinction values result in a well adapted criterion for evaluating the visual significance of regions.

Meyer proposed a graph-based implementation of these hierarchies [7],[8]. Nodes correspond to the catchment basins of the topographic surface. If two catchment basins are neighbors, their corresponding nodes are linked by an edge. The valuation of this edge is the minimum pass point of the gradient along their common frontier. In the following we will refer to this graph as the neighborhood graph. Meyer found that all the information of a hierarchy may be stored in a very condensed structure: the minimum spanning tree (MST). This is due to the fact that the flooding always follows the path of minimum height, the same that chooses the MST of the neighborhood graph. This consideration leads to a very efficient algorithm of hierarchical segmentation [7] and has also been used for interactive segmentation [12].

In [1, 2] Beucher proposed a very interesting hierarchical segmentation approach: the waterfall. Starting from the watershed result, it consists in an iterative algorithm that at each step removes all the watershed contours completely surrounded by higher ones. Typically, less than 10 hierarchical levels are produced by iterating the waterfall algorithm. In [2] each step is implemented by a reconstruction process followed by a new flooding of the resulting image. Another implementation based on graphs is also proposed in [1, 2].

The hierarchies based on extinction values produce a different level for each merging of two regions. This is useful for interactive segmentation approaches because it offers flexibility. The waterfall generates several steps of the hierarchy with an autocalibrated number of regions. This autocalibration may be interesting for segmenting generic images without imposing a given number of regions, which can be a tricky parameter to fix.

In [5] an automatic track detection application is developed using the waterfall algorithm in the initialization step. Several waterfall iterations may be necessary until a region compatible with the track geometry is found. The existing implementation of the waterfall does not allow this application in real time.

In this paper we propose an implementation of the waterfall algorithm based on the MST. It allows to access to different levels of the hierarchy in a very efficient way. Furthermore it allows the possibility to obtain different hierarchies