# Comments on "Geodesic Saliency of Watershed Contours and Hierarchical Segmentation"

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**Abstract**—In a recent paper on morphological image segmentation [1], Najman and Schmitt introduce the powerful concept of edge dynamics. In this communication, we show that the method that they propose to compute the edge dynamics gives erroneous results for certain spatial configurations, and we propose a new algorithm which always yields correct edge dynamics.

**Index Terms**—Hierarchical segmentation, watershed algorithm, basin dynamics, edge dynamics.

## 1 Introduction

THRESHOLDING of basin dynamics [2] permits to reduce the over-segmentation which usually occurs when the watershed algorithm [3] is applied to a gradient magnitude image. The concept of edge dynamics [1] permits the creation of a hierarchical representation of all segmentations that can be obtained by the basin dynamics method with different thresholds in one single image. A given segmentation can be extracted from the edge dynamics image by plain thresholding. Detailed knowledge of the watershed algorithm, basin dynamics, and edge dynamics is necessary to understand what follows. A sufficiently detailed description of these concepts can be found in [1]. Note that Fig. 16a does not correspond to Fig. 16b in [1]. To produce the flooding list in Fig. 16b, the sample function in Fig. 16a must be modified in the following way: The maximum between minima **1** and **3** must be made higher than the maximum between minima **2** and **5**, which itself must be made higher than the point **P**.

## 2 Counter-Example

Consider the spatial configuration shown in Fig. 1 and the immersion process illustrated in Fig. 2.

- Basin **c** encounters basin **a** when the immersion exceeds 5. As basin **c** has the higher minimum, it is flooded by **a** and obtains a dynamic of 5 – 3 = 2.
- Basin **b** and basin **a** enter into contact at immersion level 7. Basin **b**, having the higher minimum, is flooded by **a** and attributed a dynamic of 7 – 3 = 4.
- Basin **d** meets basin **a** when we attain immersion level 8. As basin **d** has the higher minimum, it is flooded by basin **a** and receives a dynamic of 8 – 7 = 1.

The dynamic of the basin containing the global minimum is infinite by definition.

We can suppress the basins with a dynamic lower than a preset threshold by an erosion followed by the watershed algorithm, as

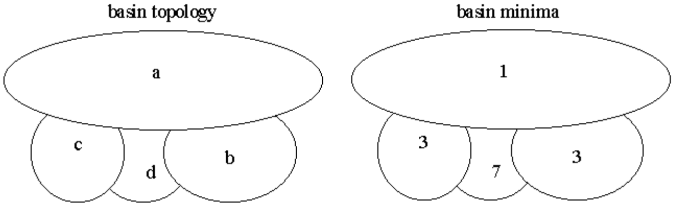


Fig. 1. The labels and the minima of the basins.

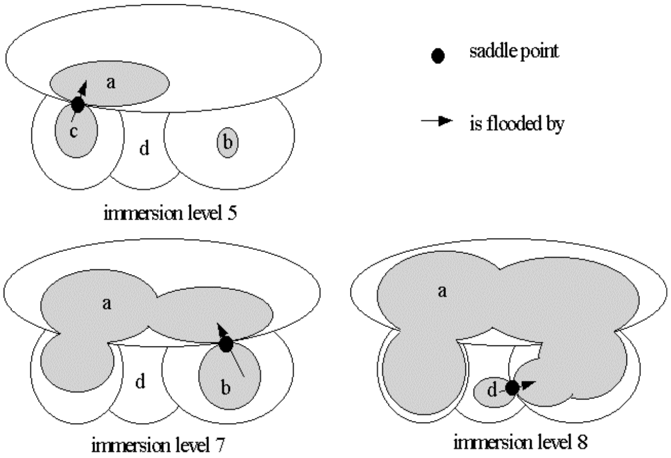


Fig. 2. Immersion process.

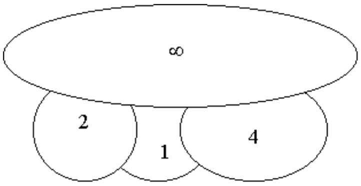


Fig. 3. Resulting basin dynamics.

described in [1]. Hence, for each new threshold, the erosion and the immersion simulation must be repeated. The concept of edge dynamics eliminates this problem. The dynamic of an edge segment corresponds to the maximum threshold for which it subsists when applying the basin dynamics method. In our example, the edge segment separating **b** and **d** subsists up to threshold 1, whereas the edge segment separating **a** and **c** subsists up to threshold 2. For a threshold superior to 4, all basins are merged. The theoretical edge dynamics are thus as shown in Fig. 4.

Najman and Schmitt [1] propose a method for evaluating edge dynamics which rely on the so-called flooding list. The flooding list for our example is shown in Fig. 5.

Consider, for example, a point **P** situated on the edge between **c** and **d**. We mark these basins and the basins by which they have successively been flooded, as shown in Fig. 6.

From Fig. 6 we see that basin **a** is the first one to be marked twice when starting from edge point **P**. We therefore attribute to **P** the maximum dynamic between the two basins which have been merged into **a** and which are marked only once. In our case, we thus take the maximum dynamic of basins **c** and **d**, i.e., a dynamic of 2. We proceed in the same manner, considering a point on each edge separing two basins. We finally obtain the attribution of dynamics shown in Fig. 7.

Upon comparison with Fig. 4 we see that this method yields erroneous edge dynamics around basin **d**. This situation occurs because the method does not take the order in which the basins are flooded into account. However, this is necessary in the two-dimensional case.

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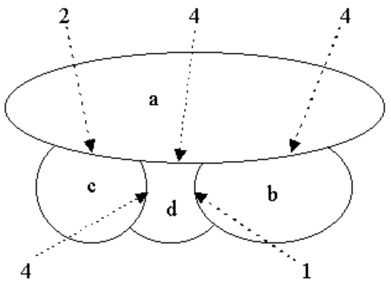


Fig. 4. Theoretical edge dynamics.

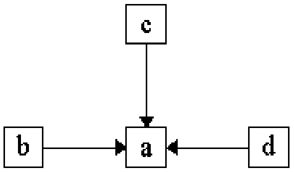


Fig. 5. Flooding list.

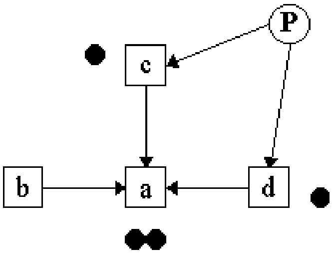


Fig. 6. Marking the list starting from an edge point P.

## 3 New Algorithm

We propose a new method for the computation of edge dynamics which includes the following steps:

1) We first construct a neighborhood graph where the basins are represented by nodes and neighboring basins are connected by arcs. Hence, an arc represents a contour segment, whose dynamic must be computed.
2) We evaluate the edge dynamics using the immersion process of the algorithm of Grimaud [2]: When attributing the dynamic of a basin, we associate it to the saddle point and, by extension, to the rest of the edge segment.
3) We traverse all possible dynamics in increasing order. On a given level *n*, we decide to merge all basins connected by an arc of dynamic *n*.
4) When an arc not yet evaluated belongs to a merged group, its dynamic is set to *n*.

As each basin floods or is flooded by another basin, we can be sure that each basin has an evaluated arc, and that there is only one group at the end. All arcs will therefore be evaluated.

The evaluation of edge dynamics in our example is thus effectuated in the following manner:

- Basin **c** is flooded by basin **a**. The dynamic of the edge segment between **a** and **c** is thus the same as the dynamic of basin **c**, i.e., 2.
- Basin **b** is flooded by basin **a**. The edge segment between **a** and **b** is thus attributed the dynamic of basin **b**, i.e., 4.
- Basin **d** is flooded by basin **a** through a saddle point situated between basin **d** and what was originally basin **b**. The dynamic of this contour is thus equal to the dynamic of basin **d**, i.e., 1.

The graph that has been constructed is next traversed:

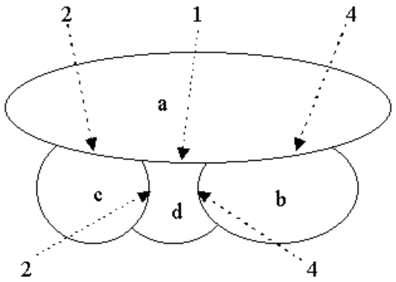


Fig. 7. Edge dynamics obtained with the method of Najman and Schmitt.

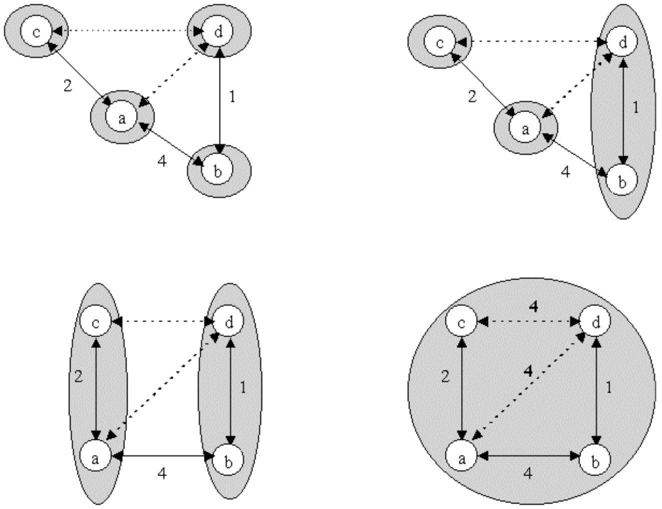


Fig. 8. Merging process.

- We merge all groups connected by an arc of dynamic 1, i.e., the groups (**b**) and (**d**) are merged.
- We merge all groups connected by an arc of dynamic 2, i.e., the groups (**a**) and (**c**) are merged.
- We merge all groups connected by an arc of dynamic 4, i.e., the groups (**b**, **d**) and (**a**, **c**) are merged.
- Now, the arcs between basins **c** and **d** and basins **a** and **d** are within the same group. We therefore set their dynamics to 4.

Fig. 8 illustrates the merging process. The resulting edge dynamics are equal to the theoretical ones shown in Fig. 4.

## 4 Conclusion

In this communication, we show that the method proposed by Najman and Schmitt [1] to evaluate edge dynamics yields erroneous results in some cases. We propose a new algorithm which, at the cost of a higher computational complexity, always gives correct edge dynamics.

## References

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