Segmentation of Ceramical Micrographies by Flooding Simulation: A Catchment Basins Merging Algorithm.

MARCOS CARNEIRO DE ANDRADE [1,2,3] GILLES BERTRAND [1]
JEAN CHRISTOPHE EVERAT [1] ARNALDO DE ALBUQUERDE ARAÚJO [2]

[1] Ecole Supérieure d'Ingénieurs en Electrotechnique et Electronique - ESIEE, Paris, France
andradem@esiee.fr, bertrandg@esiee.fr, everatj@esiee.fr

[2] Universidade Federal de Minas Gerais - UFMG/DCC, Belo Horizonte, MG
andrade@dcc.ufmg.br, arnaldo@dcc.ufmg.br

[3] Centro de Desenvolvimento da Tecnologia Nuclear - CDTN, Belo Horizonte, MG
mca@urano.cdtn.br

Abstract. This work addresses a catchment basins merging algorithm developed to automatize the segmentation of ceramical images. The proposed algorithm, which is a modification of the watershed algorithm, employs two parameters to control the catchment basins merging: a *depth* criterium and an *area* criterium. This solution suppresses the characteristic over-segmentation of the flooding simulation algorithms enabling the direct image segmentation. There is no need of a previous pre-processing step. It is shown that this solution produces excellent segmentation results.

Introduction.

Many microscopic images show a microstructure composed of individual regions separated by thin gaps. Such characteristics can be observed in some ceramic materials, as uranium oxides, in biological samples, like the cornea endothelial cells, or even in rocks like chalky. Images which present such particular tesselation of space can be directly segmented with the proposed catchment basins merging algorithm.

Image segmentation based on the watershed transformation [Beucher-90], [MeyBeu-90], [Meyer-91], [Vincent-90], has proved to be a powerfull segmentation tool. Unfortunately, its direct application to the image produces a strong over-segmentation as a result of the great number of local minima present in the original image. Often, a minima consisting of a lonely pixel can induce a segmented zone which precludes the expected boundaries detection. To achieve a suitable segmentation it is necessary to suppress these insignificant minima. To do it, a two steps procedure is usually employed: an "ïntelligent" step consisting in the extraction of significative minima, followed by a mechanical step where the watershed algorithm is applied to the image. Despite the excellent results achieved with this procedure, the image particularities and the expected segmentation results must be taken into account. Moreover, the intervention of the human judgment is often required. Alternatively, to suppress the over-segmentation, catchment basins merging algorithms based on the concept of *dynamics* [Grimaud-91] or *waterfalls* [Beucher-90] have been employed, with similar results.

Proposed Algorithm.

This work addresses a modified watershed algorithm which suppresses the markers extraction step. This modification embeds two parameters into the original non-hierarchical watershed algorithm [Vincent-90], [VinSoi-91] to control the catchment basins merging: a *depth* criterium and an *area* criterium. Both criteria are combined as rules to merge, to delay or even to prevent the catchment basins merging. The fine tunning of these criteria can lead to excellent segmentation results, near the perfect ones, presenting a very low over or under-segmentation rates, even in presence of strongly noisy images. Presently, the automation of the parameters choice is beeing considered.

Figure 1a shows the micrography of a ceramic material containing several grains, pores and bubbles. Strong noise and an irregular gradient of illumination are also present, some pores appear over the contours. The segmented image, employing the merging algorithm, is depicted in Figure 1b. It should be noted that the proposed algorithm was directly applied on the original image; no preprocessing step was done. It can be seen that almost all contours are correctly detected, despite the noise. From this segmented image it is possible to determine the grain size distribution. This method has been applied to several kinds of ceramical images producing similar results.

As the flooding process goes on, an undesirable zig-zag effect over the contours appears; this is due to a great number of local minima and noise around the grain borders. To rectify this weavy borders, a topological treatment which consists in a topological thickening

followed by a topological thinning can be used. Figure 2a presents an excerpt from Figure1 showing the zig-zag effect over the borders. Figure 2b shows the result of the topological treatment.

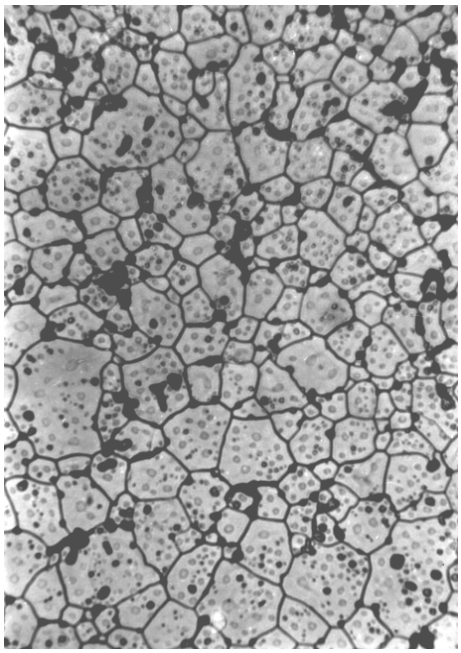

Figure 1a. Original noisy image

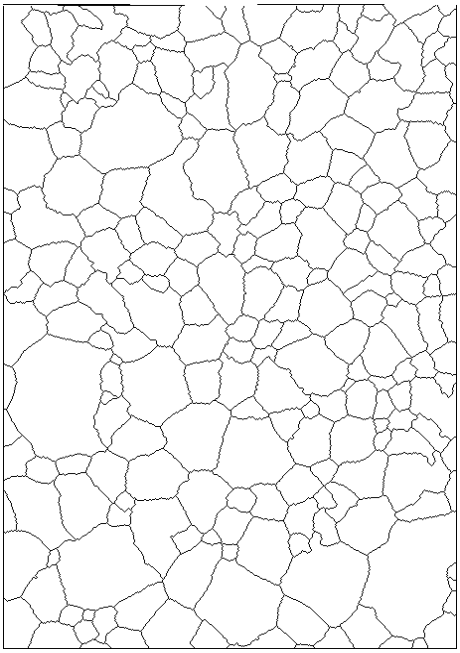

Figure 1b. Segmented image employing the proposed merging algorithm Almost all segments are correctly detected.

Conclusion.

The proposed catchment basins merging solution, which is based on some topological properties of the image, allows the suppression of the traditional over-segmentation found in the original watershed algorithm. It avoids the minima detection step and enables the automatic characterization of diverse materials from their segmented images.

Figure 2a. Zig-zag effect on the borders

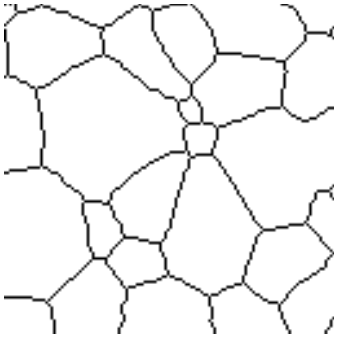

Figure 2b. Result of topological treatment.

References

L. Vincent. Algorithmes Morphologiques a base de Files d'Attente et de Lacets. Extension aux Graphes. École Nationale Supérieure de Mines de Paris, PhD thesis, 1990.

L. Vincent and P. Soille. Watersheds in Digital Spaces: An Efficient Algorithm Based on Immersion Simulations. Transactions on Pattern Analysis and Machine Intelligence, v. 13, n. 6, jun 1991.

S. Beucher. Segmentation d'Image et Morphologie Mathematique. École Nationale Supérieure de Mines de Paris, PhD thesis, 1990.

M. Grimaud. La geodesie Numerique en Morphologie Mathematique. Application a la Detection Automatique de Microcalcifications en Mammographie Numerique, École Nationale Supérieure de Mines de Paris, PhD thesis, 1991.

Meyer F. Un Algorithme Optimal de Ligne de Partage des Eaux. Congress AFCET, RFIA, Lyon, 1991.

Meyer F. Beucher S. Morphological Segmentation. Journal of Visual Communication and Image Representation, v.1, n. 1, sept 1990.