TRANSFORMATIONS WITH RECONSTRUCTION CRITERIA: IMAGE SEGMENTATION AND FILTERING

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Abstract In this paper, a class of transformations with reconstruction criteria, derived from the reconstruction transformations, is investigated. The idea to build these transformations consists in stopping the reconstruction process according to a size criterion. This class of transformations was initially proposed for obtaining intermediate results between the morphological opening and the opening by reconstruction. Here, the transformations are presented in the general case, as in the reconstruction transformations case, by imposing some conditions on the marker. We show that the set of markers for the transformations with reconstruction criteria is given by the set of dilated images. The interest of these transformations in image segmentation is shown. Also the notion of granulometry and the alternating sequential filters are investigated.

Keywords: Opening and closing by reconstruction, opening and closing with reconstruction criteria, filtering, segmentation

1. Introduction

In mathematical morphology (MM), the watershed-plus-markers approach is the traditional image segmentation method. This technique requires to correctly know the different morphological tools for extracting the markers. Among these tools, morphological filtering plays a fundamental role not only as a tool for symplifying the input image, but also for detecting markers. The basic morphological filters are the morphological opening and closing with a given structuring element. However, even if this type of filters permits the removal of undesirable regions, frequently, the remaining structures are modified. A way of attenuating this inconvinience is the use of the well-known filters by reconstruction. These filters that form a class of connected filters, process

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separately each connected component. Nevertheless, the main drawback of the filters by reconstruction is that they reconstruct *too much*, the so-called leakage problem, and sometimes it is not possible to extract the regions of interest. In other words, there is no way of controlling the reconstruction process. Several solutions have been proposed by Salembier and Oliveras [10], Tzafestas and Maragos [8], Serra [3], Terol-Villalobos and Vargas-Vázquez [4, 5], Vargas-Vázquez et *al.* [6] among others. In particular, Serra [3] characterizes the concept of viscous propagations by means of the notion of viscous lattices. In his work, Serra defines a connection on the viscous lattices which does not connect *too much* allowing to separate arc-wise connected components into a set of connected components in the viscous lattices sense. On the other hand, Terol-Villalobos and Vargas-Vázquez [4, 5] , introduce the notion of reconstruction criterion which allows the reconstruction to be stopped. In the present work, the reconstruction criterion will be used to introduce the transformations with reconstruction criteria. One shows that these transformations have a similar behavior than a class of transformations introduced by Serra in [3]. Also, the interest of building other transformations for segmenting and filtering images, is shown.

2. Morphological Filtering

The basic morphological filters are the morphological opening $\gamma_{\mu B}$ and the morphological closing $\varphi_{\mu B}$ with a given structuring element. In this work, B is an elementary structuring element (3x3 pixels) containing its origin, $\check{B}$ is the transposed set ($\check{B} = \{-x : x \in B\}$) and μ is an homothetic parameter. The morphological opening and closing are given, respectively, by:

$$\gamma_{\mu B}(f)(x) = \delta_{\mu \check{B}}(\varepsilon_{\mu B}(f))(x) \quad \text{and} \quad \varphi_{\mu B}(f)(x) = \varepsilon_{\mu \check{B}}(\delta_{\mu B}(f))(x) \tag{1}$$

where $\varepsilon_{\mu B}(f)(x) = \wedge\{f(y) : y \in \mu \check{B}_x\}$ and $\delta_{\mu B}(f)(x) = \vee\{f(y) : y \in \mu \check{B}_x\}$ are the morphological erosion and dilation, respectively. $\wedge$ is the inf operator and $\vee$ is the sup operator. In the following, we will suppress the set B. The expressions γ_μ,$\gamma_{\mu B}$ are equivalent (i.e. $\gamma_\mu = \gamma_{\mu B}$). When the parameter μ is equal to one, all parameters are suppressed (i.e. $\delta_B = \delta$).

Openings and Closings by Reconstruction

An interesting class of filters, called the filters by reconstruction, are built by means of the geodesic transformations [7]. In the binary case, the geodesic dilation (resp. erosion) of size 1 of a set Y (the marker) inside the set X is defined as $\delta^1_X(Y) = \delta(Y) \cap X$ (resp. $\varepsilon^1_X(Y) = \varepsilon(Y) \cup X$), while in the gray-level case is given by $\delta^1_f(g) = f \wedge \delta_B(g)$ (resp. $\varepsilon^1_f(g) = f \vee \varepsilon_B(g)$). When filters by reconstruction are built, the geodesic transformations are iterated until idempotence is reached. Consider two functions f and g, with $f \geq g$