IMAGE FILTERING USING MORPHOLOGICAL AMOEBAS

Romain Lerallut, Étienne Decencière and Fernand Meyer
Centre de Morphologie Mathématique, École des Mines de Paris
35 rue Saint-Honoré, 77305 Fontainebleau, France
lerallut@cmm.ensmp.fr

Abstract This paper presents morphological operators with non-fixed shape kernels, or amoebas, which take into account the image contour variations to adapt their shape. Experiments on grayscale and color images demonstrate that these novel filters outperform classical morphological operations with a fixed, space-invariant structuring element for noise reduction applications.

Keywords: Anisotropic filters, noise reduction, morphological filters, color filters

1. Introduction

Noise is possibly the most annoying problem in the field of image processing. There are two ways to work around it: either design particularly robust algorithms that can work in noisy environments, or try to eliminate the noise in a first step while losing as little relevant information as possible and consequently use a normally robust algorithm.

There are of course many algorithms that aim at reducing the amount of noise in images. Most are quite effective but also often remove thin elements such as canals or peninsulas. Even worse, they can displace the contours and thus create additional problems in a segmentation application.

In mathematical morphology we often couple one of these noise-reduction filters to a reconstruction filter that attempts to reconstruct only relevant information, such as contours, and not noise. However, a faithful reconstruction can be problematic when the contour itself is corrupted by noise. This can cause great problems in some applications which rely heavily on clean contour surfaces, such as 3D visualization, so a novel approach was proposed.

C. Ronse et al. (eds.), Mathematical Morphology: 40 Years On, 13–22.

2. Amoebas: dynamic structuring elements

Principle

Classic filter kernel. Formally at least, classic filters work on a fixed-size sliding window, be they morphological operators (erosion, dilation) or convolution filters, such as the diffusion by a Gaussian. If the shape of that window does not adapt itself to the content of the image (see figure 1), the results deteriorate. For instance, an isotropic Gaussian diffusion smooths the contours when its kernel steps over a strong gradient area.

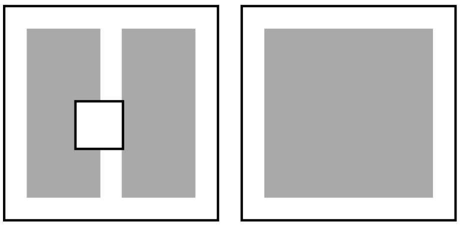

Figure 1 Closing of an image by a large structuring element. The structuring element does not adapt its shape and merges two distinct objects.

Amoeba filter kernel. Having made this observation, Perona and Malik [1] (and others after them) have developed anisotropic filters that inhibit diffusion through strong gradients. We were inspired by these examples to define morphological filters whose kernels adapt to the content of the image in order to keep a certain homogeneousness inside each structuring element (see figure 2). The coupling performed between the geometric distance between pixels and the distance between their values has similarities with the work of Tomasi and Manduchi described in [5].

The interest of this approach, compared to the analytical one pioneered by Perona and Malik is that it does not depart greatly from what we use in mathematical morphology, and therefore most of our algorithms can be made to use amoebas with little additional work. Most of the underlying theoretical groundwork for the morphological approach has been described by Jean Serra in his study [2] of structuring functions, although until now it has seen little practical use.

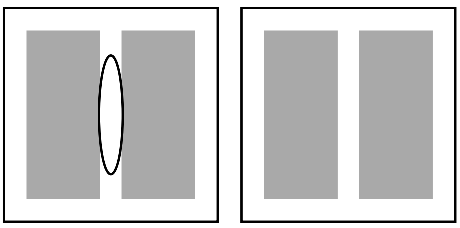

Figure 2 Closing of an image by an amoeba. The amoeba does not cross the contour and as such preserves even the small canals.

The shape of the amoeba must be computed for each pixel around which it is centered. Figure 3 shows the shape of an amoeba depending on the position of its center. Note that in flat areas such as the center of the disc, or the