DOWNSAMPLING OF BINARY IMAGES USING ADAPTIVE CROSSING NUMBERS

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Abstract A downsampling method for binary images is presented, which aims at preserving the topology of the image. It uses a general reference sampling structure. The reference image is computed through the analysis of the connected components of the neighborhood of each pixel. The resulting downsampling operator is auto-dual, which ensures that white and black structures are treated in the same way. Experiments show that the image topology is indeed preserved, when there is enough space, satisfactorily.

Keywords: Digital topology, binary downsampling, reference downsampling

1. Introduction

In this era of expanding mobile multimedia devices, small screens will soon be in every pocket. Their relatively small resolutions (a PDA screen is typically 320 by 320 pixels) pose display problems, worsened by the fact that visual digital documents are often thought for high resolution displays. For example, how can a faxed document, or a tourist brochure, which has been scanned with a 200 dpi resolution, be conveniently displayed on a PDA screen?

As it can be seen, we are confronted with a severe downsampling problem. Moreover, these images often are binary or nearly so, like faxes, diagrams, maps, etc. In these particular cases, classical downsampling methods work very badly, because they aim at removing from the image those structures which cannot be represented at the lower resolution level. For example, depict a thin black line on a white background. If downsampled with a classical linear method (i.e. high frequencies are filtered out before downsampling), this line will be smoothed away. If we require that the resulting image is binary, thin structures might be simply erased. In many application domains this is a normal, and welcome, feature. However, when displaying graphical data on small displays, the opposite might be more interesting, that is, preserving small

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structures when there is enough place in the image. In other words, we want, if possible, to preserve the homotopy of the initial image.

In this paper, focus is on the problem of nice downsampling of binary images. After this introduction, we will define the problem, and review existing methods. Then, in section 3 we will introduce a general adaptive downsampling scheme which will be used as basis in the following section for a binary downsampling method which aims at preserving homotopy. In the next section results are presented and commented. Finally, conclusions are drawn.

Demonstrations, which are quite simple, are not given for lack of space. They are included in a technical report [4].

2. Framework and objectives

Only binary images will be considered in this paper. They typically correspond to text, diagrams, graphics, or maps.

Thin and small structures in binary images are often semantically very important. Therefore, we want to preserve them through the downsampling procedure as long as it is possible. In other words, and borrowing vocabulary from the image compression world, we can say that we want to achieve *graceful degradation* of the information.

Of course, the detection of what is important is not trivial, nor is easy to know how long it is possible to preserve data which is considered meaningful. On the other hand, we are not subject to one important constraint that most downsampling methods try to satisfy : reversibility. Indeed, most downsampling methods propose an up-sampling operator such that the reconstructed image is as close as possible to the original one. The idea behind reversibility is to limit the loss of data. In our case, we do not aim at this characteristic because we pretend to preserve semantic information, and we suppose that the image topology is directly related to this information.

We do not know beforehand if the important structures of a binary image are black or white. Therefore, we will treat them in the same way. In other words, the downsampling method should be *auto-dual*.

3. State of the art

The classical linear downsampling approach is based on the removal from the original image of those frequencies which are too high to be represented at the lower resolution level. This is clearly not adapted to our framework, where high frequencies convey often important semantic information. For example, a thin line would be blurred or erased by such methods.

Morphological downsampling methods are also based on the same idea [8, 9, 7] : first, they remove those structures which are considered too small to