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AN EFFICIENT IMAGE SIMPLIFICATION ALGORITHM FOR BRAIN MRI SEGMENTATION BASED ON DOWNHILL FILTER

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Abstract. Image simplification, which reduces the information content of an image to suppress undesired details such as noise, is a very important basic ingredient of a lot of practical applications. The simplification of human brain MRI (Magnetic Resonance Imaging) is one of essential pre-processing steps for medical researches and clinical applications. Usually, the process of image simplification requires multiple iterations of reconstruction. Therefore, the efficiency of the reconstruction algorithm is a key problem. This paper has proposed an efficient reconstruction algorithm for MRI brain image simplification based on downhill filter. The main contribution of this paper is to use the regional maxima concept to modify the initialization condition of downhill filter algorithm. Experimental results show that the efficiency of this algorithm is much better than that of fast hybrid reconstruction algorithm, and it can achieve good result when it is used to the contour extraction from the MRI of human brain.

Key words. MRI, Human Brain Image Simplification, Morphological Reconstruction, and Downhill Filter.

1. Introduction

The research on the segmentation of interest regions of medical image is the most important basis of the medical image analysis. Watershed transform is a common technique for image segmentation which has been widely used in many fields of image processing, including medical image segmentation. However, if the watershed transform is applied directly to image segmentation, the problem of over-segmentation caused by insignificant structures or noise will be very serious. So image segmentation is typically done by preprocessing, and then using the watershed transform[1]. The purpose of pre-processing is to remove the image details, which are not necessary to the segment and to produce flat zones. This process is usually called image simplification.

In recent years, several morphological reconstruction filters have been developed as tools for image simplification. These filters indeed produce flat zones while preserving the contour information. The classical filter is morphological reconstruction by dilation which is first proposed by Serra[2]. Then there are many varied instances of this kind filter, but there is a problem: the inefficiency of the 'iterate until convergence' approach. So a number of optimizations and algorithmic efficiencies have been detailed for this and similar procedures in both binary and grayscale morphology including structuring element decomposition [3] and manipulation[4, 5], flat zones [6], interval coding [7], and the use of ordered pixel queues [8]. These algorithms have a common drawback that is the procedure still remains computationally expensive and highly data dependant.

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In order to enhance the computing speed, Robinson proposed an efficient morphological reconstruction method which is called the downhill filter [9]. This is an improved algorithm based on the alternative reconstruction by dilation procedures. It can achieve the same filtering effect in a single pass through the data and as such is both fast and linear time in its execution. But the downhill filter usually remains brighter regions because this algorithm targets MRCP (Magnetic Resonance Cholangiopancreatography) data. Thus, in this paper, downhill filter algorithm will be improved to be better for the MRI brain image simplification.

2. Morphological Reconstruction

The reconstruction transformation[10] is relatively well-known in the binary case,where it simply extracts the connected components of an image which are "marked" by another image. However, reconstruction can be defined for grayscale images, where it turns out to be extremely useful for several image analysis tasks. It can be thought of conceptually as repeated dilations of an image, called the marker image, until the contour of the marker image fits under a second image, called the mask image. In morphological reconstruction, the peaks in the marker image "spread out," or dilate. Each successive dilation operation is forced to lie underneath the mask. When further dilations do not change the marker image any more, the processing is finished. The final dilation creates the reconstructed image. The most commonly used algorithm is alternative definition of grayscale reconstruction which is defined as follows:

Let J and I be two grayscale images defined on the same domain, taking their valuesin the discrete set $\{0, 1, \ldots, N-1\}$ and such that $J \leq I$ (i.e.,for each pixel $p \in D_1, J(p) \leq I(p)$). The elementary geodesic erosion ${\delta_I}^{(1)}$ of grayscale image $J \leq I$ above I is given by

$$\delta_I^{(1)}(J) = (J \oplus B) \wedge I \tag{1}$$

In this equation,$\wedge$ stands for the pointwise minimum and $J \oplus B$ is the dilation of J by flat structuring element B. These two notions are the direct extension to the grayscale case of respectively intersection and binary dilation by B. The grayscale geodesic dilation of size $n \geq 0$ is then given by

$$\delta_I^{(n)}(J) = \underbrace{\delta_I^{(1)} \circ \delta_I^{(1)} \circ \cdots \circ \delta_I^{(1)}(J)}_{n\ times} \tag{2}$$

The grayscale reconstruction $\rho_I(J)$ of I from J is given by

$$\rho_I(J) = \bigvee_{n \geq 1} \delta_I^{(n)}(J) \tag{3}$$

There are four algorithms described in [10] for the two dimensional eight connected and three dimensional six connected cases:

A Standard Technique: this algorithm works by iterating elementary dilation followed by pointwise minimum until stability. It is not suited to conventional computers, because the image pixels can be scanned in an arbitrary order. It requires the iteration of numerous complete image scanning, sometimes several hundreds.