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Image Segmentation by Improved Watershed Transformation in Programming Environment MATLAB

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ABSTRACT

Image segmentation is the foundation of object recognition and computer vision. Watershed transform is usually adopted for image segmentation in the area of image processing and image analysis because it always generates closed contours for each region in the original image. The concept of watershed transform is based on a processing simulating the immersion of a landscape in a lake that is dams have to be built to prevent the merging of different catchment basins. But the watershed transformation leads to over segmentation. In this paper we will discuss the image segmentation by improved watershed transformation in MATLAB programming environment.

Keywords: Morphological Reconstruction, Recognition, Watershed Transformation

1. INTRODUCTION

Image segmentation is an important and, perhaps, the most difficult task in image processing. Segmentation refers to the grouping of image elements that exhibit "similar" characteristics, i.e. subdividing an image into its constituent regions or objects. All subsequent interpretation tasks, such as object recognition and classification, rely heavily on the quality of the segmentation process. There are many applications whether on synthesis of the objects or computer graphic images require precise segmentation. In general, image noise should be eliminated through image preprocessing. And there is some specifically-given work (such as region extraction and image marking) to do after the main operation of image segmentation for the sake of getting better visual effect [1].

Watershed transform has long been admitted as a useful tool in image segmentation. The watershed lines can effectively divide individual catchment basins in a gradient image and generate closed contours for each region in the original image. The methodologies of image segmentation based upon watershed transform have been developed and improved during the past decade. Numerous researches have been conducted for obtaining watershed lines. For example, Beucher [1] proposed an effective watershed algorithm by using markers. On the other hand, Vincent et al. [10] proposed a famous watershed algorithm called "*immersion algorithm*", which provides an effective and efficient implementation for watershed transform.

Beucher [1] categorized watershed algorithms into two groups. The algorithms in the first group like immersion algorithm [2] simulate the flooding process. The immersion algorithm is one of the most famous watershed segmentation algorithms. It offers an efficient way to extract watershed lines by simulating the immersion process on gradient images. The second group of watershed algorithms aims at direct detection of watershed lines.

Over-segmentation is a significant problem for most watershed algorithms, which were addressed in numerous literatures [1-5]. Conventionally, watershed transform is mostly designed for the purpose of image segmentation. In this paper we will discuss the image segmentation by improved watershed transformation which is gives better result than traditional watershed transformation in MATLAB programming environment and reduces over segmentation...

2. WATERSHED TRANSFORMATION

Watershed transform, which is originally proposed by Digabel and Lantuejoul [6][7], has been widely adopted in image segmentation. The methodologies of watershed-based image segmentation have been steady developed and improved during the past decade. Generally speaking, watershed transform can be classified as a region-based image segmentation approach.

However, the purpose of watershed transform is not limited in image segmentation, i.e. results generated by watershed transform can be taken as preprocesses for further image analysis. The idea of watershed transform is straightforward by the intuition from geography. Imagine a landscape which is immersed in a lake, catchment basins will be filled up with water starting at each local minimum. At the points (or lines) where water coming from different catchment basins would meet, dams must be built to avoid the merging of catchment basins. After the water level has reached the highest peak in the landscape, all catchment basins are divided by dams, which are called watershed lines. As a result, watershed lines can separate individual catchment basins in the landscape.

3. IMPROVED WATERSHED TRANSFORM

The steps of improved watershed transformation are given below:

3.1. Morphological Reconstruction

Morphological reconstruction can keep the information of object contours when filtering the image. Based on dilation, morphological reconstruction has these unique properties: Processing is based on two images, a marker and a mask, rather than one image and a structuring element. Processing repeats until stability; i.e., the image no longer changes.

In Matlab., IMRECONSTRUCT Performs morphological reconstruction.

IM = Imreconstruct (Marker, Mask)

performs morphological reconstruction of the image MARKER under the image MASK. MARKER and MASK can be two intensity images or two binary images with the same size; IM is an intensity or binary image, respectively. MARKER must be the same size as MASK, and its elements must be less than or equal to the corresponding elements of MASK.

Morphological structuring element can be created using strel. Its syntax is:

SE = Strel(Shape, Parameters)

creates a structuring element, SE, of the type specified by shape. Depending on shape, strel can take additional parameters. Flat Structuring elements like Line, disk, rectangle, square, octagon, Diamond, periodic, Arbitrary.

Consider the original image.

Fig. 1: Original Image

Create a structuring element of the type specified by shape disk. In morphological opening, erosion typically removes small objects, and the subsequent dilation tends to restore those objects that remain.

After applying Morphological opening reconstruction on the original image, perform morphological reconstruction of the image MARKER image under the image MASK f and then apply morphological closing reconstruction. Morphological closing reconstruction is computed by complementing an image, followed by opening reconstruction and followed by complementing the result.

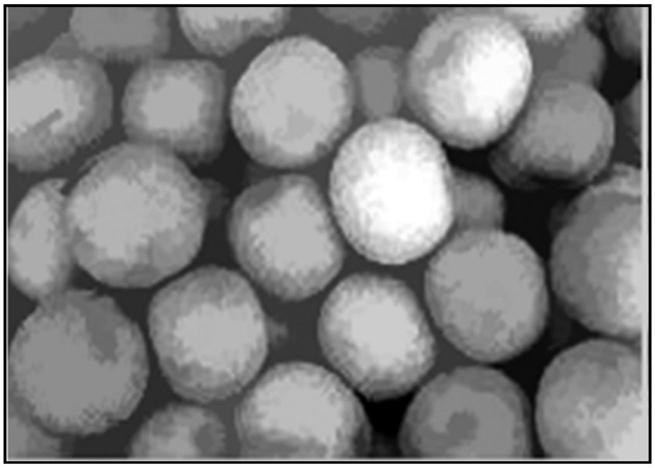

Fig. 2: After Morphological Reconstruction

3.2. Morphological Gradient Calculation

Morphological gradient operation give sharp transition at grey level discontinuity, after the processing of opening/closing reconstruction, the gradient image is obtained by morphological gradient calculation. In Matlab, Morphological gradient operation is computed by subtracting the eroded image from dilated image.

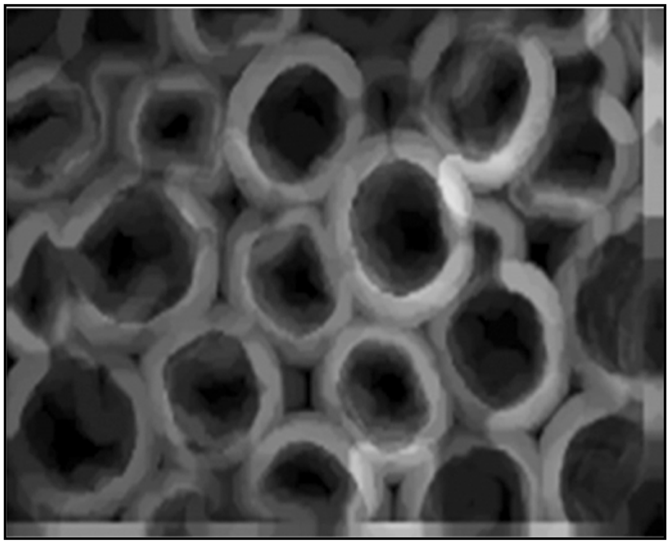

Fig. 3: After Morphological Gradient

3.3. Nonlinear Transformation of Gray Level

The Webber perception principle, means difference of gray level W(I) that can be discriminated by human eye is a nonlinear function of the gray level I, the simplest Webber perception function is

$$W(I) = \begin{cases} 20 - \dfrac{12I}{88} & 0 \le I \le 88 \\ 0.002(I-88)^2 & 88 \le I < 138 \\ \dfrac{7(I-138)}{255-138} + 13 & 138 \le I \le 255 \end{cases} \quad (1)$$

According to the Webber perception principle, Human eye can hardly discriminate the differences of gray levels between $[I(n), I(n) + W(I(n))]$, then we can regard the gray levels between $[I(n), I(n) + W(I(n))]$ as the same gray level.

1. Set the iteration number $n = 1$, the beginning gray level $I(n) = 0$.
2. Calculate the value of $W(I(n))$ corresponding to $I(n)$ by Webber perception principle.
3. In the morphological gradient image $G(f2)$, set the gray level of all points whose gray level is between $[I(n),I(n)+W(I(n))]$ to $I(n) + W(I(n))$.
4. Search the points whose gray level is higher than $I(n) + W(I(n))$ in $G(f2)$. If these points does NOT exist, the iteration ends, or find the lowest gray level Imin in these points, increase the iteration number $n = n+ 1$, and set $I(n)$= Imin, then turn to step 2.

After applying the algorithm in matlab, we get the resultant image as given below.

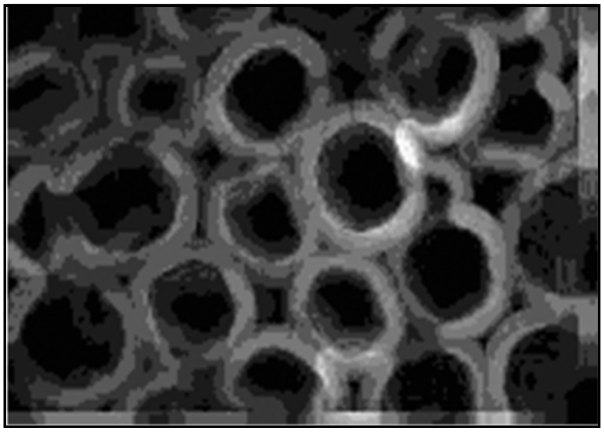

Fig. 4: After Applying Webber Perception Principle

4. EXPERIMENTAL RESULT

After applying watershed on the image obtained from applying the algorithm of webber perception principle, the resultant image is given below which is better than traditional watershed transformation.

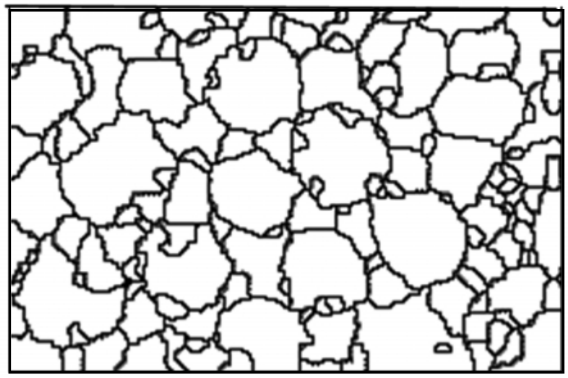

Fig. 5: After Improved Watershed Transformation

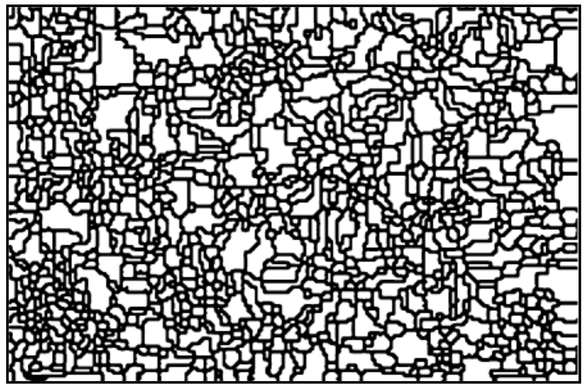

Fig. 6: Traditional Watershed Transformation

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