Image Segmentation using Watershed Transform

Amandeep Kaur, Aayushi

Abstract— Image segmentation is one of the most important categories of image processing. The purpose of image segmentation is to divide an original image into homogeneous regions. It can be applied as a pre-processing stage for other image processing methods. There exist several approaches for image segmentation methods for image processing. The watersheds transformation is studied in this report as a particular method of a region-based approach to the segmentation of an image. First, the basic tool, the watershed transform is defined. It has been shown that it can be implemented by applying flooding process on grey tone image. This flooding process can be performed by using basic morphological operations. The complete transformation incorporates a pre-processing and post-processing stage that deals with embedded problems such as edge ambiguity and the output of a large number of regions. Watershed Transform can be applied to gray scale images, textural images and binary images. The watershed transform has been widely used in many fields of image processing, including medical image segmentation.

Index Terms— flooding, Gradiant, Segmentation, Watershed Transform,

I. INTRODUCTION

The image segmentation algorithms are generally based on the two basic characteristics of the luminance: discontinuity and similarity.[1] Edge detection algorithms are based on the discontinuity. Similarly, the threshold processing, region growing, regional separation and polymerization are based on similarity. Watershed algorithm which is a mathematics morphological method for image segmentation based on region processing, has many advantages. The result of watershed algorithm is global segmentation, border closure and high accuracy. It can achieve one-pixel wide, connected, closed and exact location of outline. The basic concept of watershed is based on visualizing a gray level image into its topographic representation, which includes three basic notions: minima, catchment basins and watershed lines. In the image of Fig.1.1, if we imagine the bright areas have "high" altitudes and dark areas have "low" altitudes, then it might look like the topographic surface illustrated by Fig. 1.2. In this surface, it is natural to consider three types of points: (1) points belonging to the different minima; (2) points at which water would fall with certainty to a single minimum; and (3) points at which water would be equally likely to fall to more than one minimum.[1] The first type of points forms different minima of the topographic surface. The second type points which construct a gradient interior region is called catchment basin.

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The third type of points form crest lines dividing different catchment basins, which is termed by watershed lines[1][4].

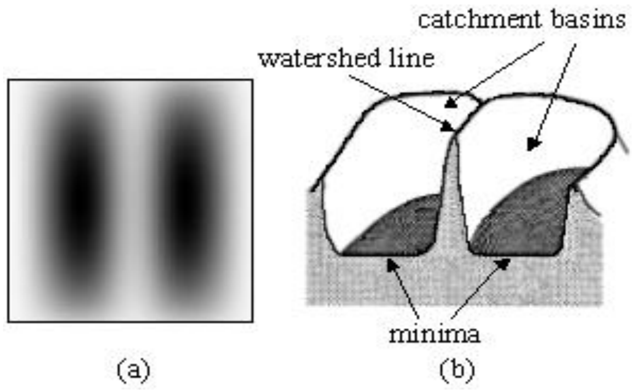

Fig. 1.1 A gray level image   Fig.1.2 The topographic surface of (1.1)

The paper is organized as follows. Section 2 contains watershed transform. Section 3 and 4 contain proposed algorithms and section 5 contains experimental results

II. WATERSHED TRANSFORM

The algorithm introduced by Luc Vincent and Pierre Soille is based on the concept of "immersion". Each local minima of a gray-scale image I which can be regarded as a surface has a hole and the surface is immersed out into water. Then, starting from the minima of lowest intensity value, the water will progressively fill up different catchment basins of image (surface) I. Conceptually, the algorithm then builds a dam to avoid a situation that the water coming from two or more different local minima would be merged. At the end of this immersion process, each local minimum is totally enclosed by dams corresponding to watersheds of image (surface) Figure 1.1 shows this procedure graphically[1].

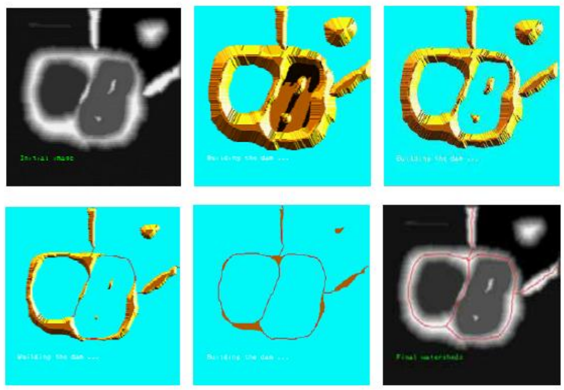

Fig 2.1 Flooding process in watershed transform

The watershed transform has been widely used in many fields of image processing, including medical image segmentation, due to the number of advantages that it possesses: it is a simple intuitive

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method, it is fast and can be parallelized and an almost linear speedup was reported for a number of processors up to 64) and it produces a complete division of the image in separated regions even if the contrast is poor, thus avoiding the need for any kind of contour joining. It is appropriate to use this method to segment the high-resolution remote sensing image[1][3][5]

III. WATERSHED IMPLEMENTATION METHODS

There are mainly three methods to implement watershed. They are listed below:

- ❑ Distance Transform Approach
- ❑ Gradient method
- ❑ Marker Controlled Approach

A. Distance Transform Approach

A tool used commonly in conjunction with the watershed transform for segmentation is the distance transform. It is the distance from every pixel to the nearest nonzero-valued pixel. The distance transform can be computed using toolbox function bwdist, whose calling syntax is

D=bwdist(f)

A binary image can be converted to a gray level image, which is suitable for watershed segmentation using different DT. However, different DT functions produce different effects. Euclidean DT has a higher possibility of “salt and pepper” over segmentation. City Block DT has a higher possibility of over segmentation for the components in the image. The reason is that City Block DT propagates to the neighbourhood in the shape of diamond. Chessboard DT has a better pruning effect due to its square shape propagation. It can effectively remove the jaggedness formed in the Euclidean DT and avoid the components over segmentation caused by City Block DT[4].

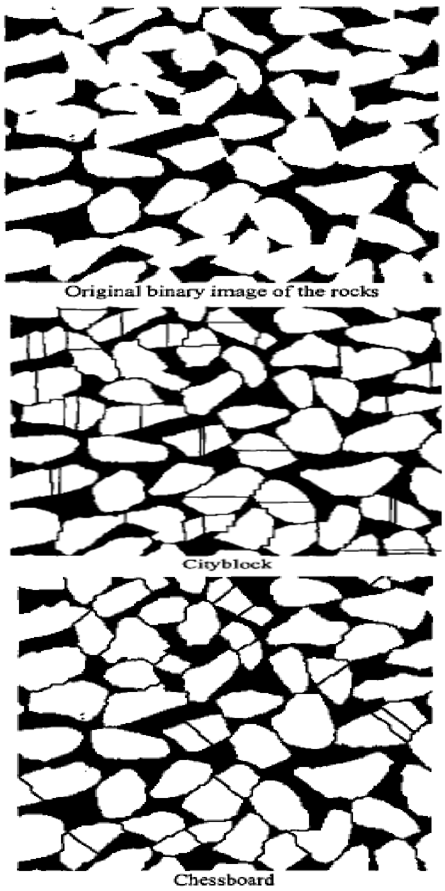


Fig. 3.1 The watershed segmentation results for the binary image of the rocks with different DTs.

B. Gradient Method

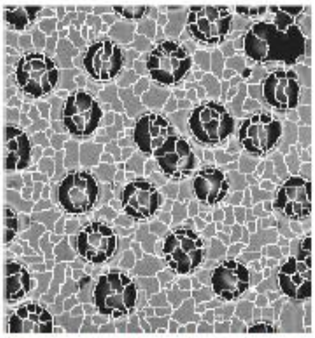
The gradient magnitude is used to pre process a gray-scale image prior to using the watershed transform for segmentation. The gradient magnitude image has high pixel values along object edges and low pixel values everywhere else. Watershed transform would result in watershed ridge lines along object edges[2]. There is a problem of over segmentation in this method. The topological gradient provides a global analysis of the image then the almost unwanted contours due to the noise added to a given image can be significantly reduced by our approach. The experimental results show that the over segmentation problem, which usually appears with the watershed technique, can be attenuated, and the segmentation results can be performed using the topological gradient approach. Another advantage of this method is that it splits the segmentation process into two separate steps: first we detect the main edges of the image processed, and then we compute the watershed of the gradient detected[1][2].

C. Marker Controlled Methods

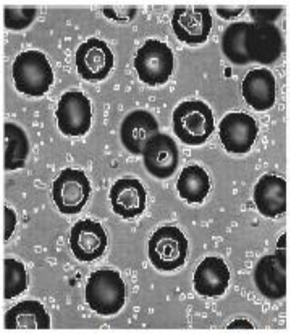
Direct application of watershed transform to a gradient image can result in over segmentation due to noise. Over segmentation means a large number of segmented regions. An approach used to control over segmentation is based on the concept of markers. A marker is a connected component belonging to an image. Markers are used to modify the gradient image. Markers are of two types internal and external, internal for object and external for boundary[7]. The marker-controlled watershed segmentation has been shown to be a robust and flexible method for segmentation of objects with closed contours, where the boundaries are expressed as ridges. Markers are placed inside an object of interest; internal markers associate with objects of interest, and external markers associate with the background. After segmentation, the boundaries of the watershed regions are arranged on the desired ridges, thus separating each object from its neighbours [1][7][11][12].

IV. EXPERIMENTAL RESULTS

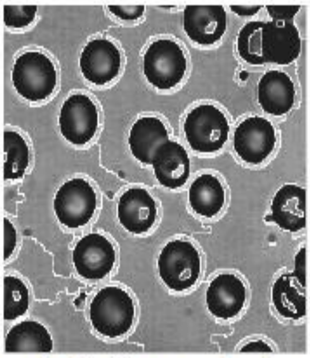
In this section, we present experimental result to demonstrate the performance of the watershed technique. The performance of the method under the presence of intense noise is also analysed, and the results are compared with other segmentation methods. The results of cellular images and their corresponding watershed images are shown in Fig.4 (a)–(d), respectively. From the segmentation results, the continuous and thin closed contours can be clearly identified by the given watershed algorithm[10].



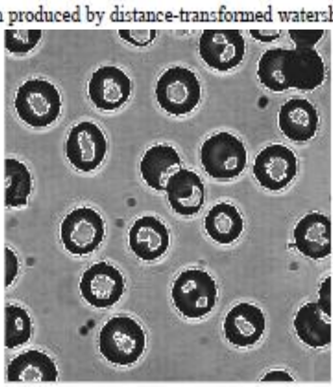
(a) Segmentation produced by traditional watershed algorithm based on Gradient image;



(b) Segmentation produced by marker-controlled watershed algorithm



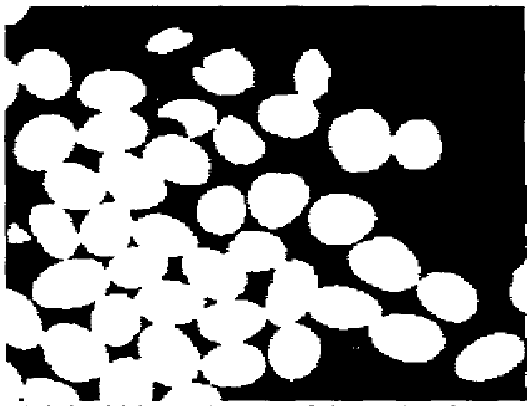
(c) Segmentation produced by distance-transformed watershed algorithm;



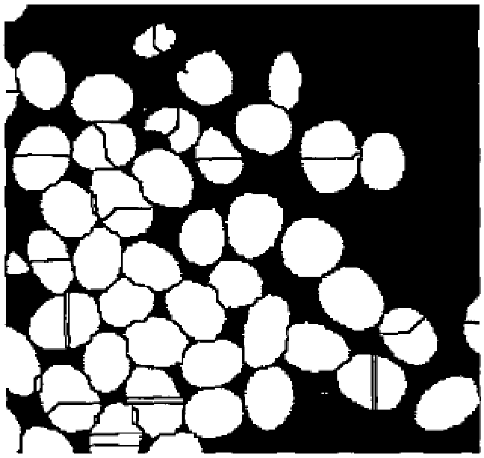
(d) Segmentation produced by the proposed watershed algorithm.

Fig.4.1 Compared with other traditional methods.

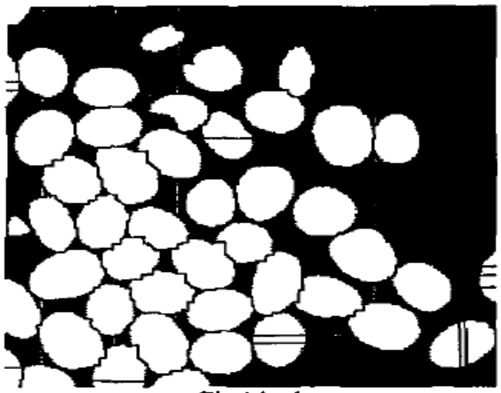
Here we show another example of watershed segmentation effects with different DTs for the binary images of coffee beans. The shape of coffee beans are more close to ellipse. Fig.4.2 shows the watershed segmentation results for the binary image of the coffee beans with different DTs. Examples show that the Chessboard DT achieves the best watershed segmentation result among the three different DTs[4].



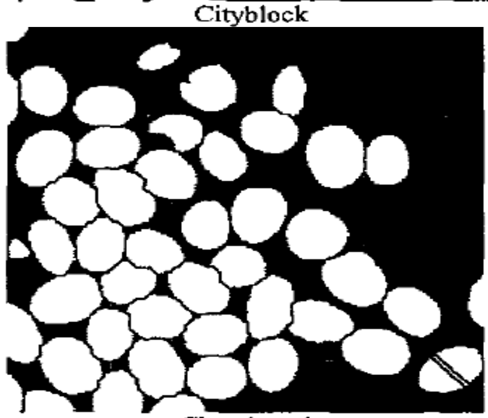
Original binary image of the coffee beans



Euclidean



Cityblock



Chessboard

Fig. 4.2. The watershed segmentation results for the image of the coffee beans with different DTs

V. CONCLUSION

Watershed transform is a powerful tool for the purpose of image segmentation. However, the purpose of watershed transform is not limited in image segmentation. For images containing components of different shapes, we find that the Chessboard DT can achieve better watershed segmentation results than Euclidean DT and City block DT[4]. Also, Marker controlled method is much effective in segmentation as it significantly reduces the number of minima's[11].

VI. FUTURE WORK

Image processing is very hot field which needs extensive research and hard work. Following are the suggestions for future work.

1. Improve the speed by using parallel processing either on clusters system or multiprocessor System [6][7][8][9].
2. Merge this technique with some other technique to get the better results[3].

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