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Objects Counting Using Mark-Controlled Watershed Transform

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Abstract: This paper introduces the object counting using the mark controlled watershed transforms. 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. This method is good choice for image segmentation in the field of mathematical morphology. In this paper we are separating the foreground touching objects in an image. The watershed transform is often applied for this problem. The watershed transform finds "catchment basins" and "watershed ridge lines" in an image by treating it as a surface where light pixels are high and dark pixels are low. Segmentation using the watershed transforms works well if we can identify, or "mark," foreground objects and background locations. In this paper we will discuss the image segmentation by improved watershed transformation in MATLAB programming environment.

Key Words: Watershed Transform, Mathematical watershed definition, Image segmentation, Morphological operation.

1. Introduction

The idea of watershed transform has been introduced in 1979 by S. Beucher and C. Lantuéjoul [1].In watershed segmentation water source is placed in each regional minimum, to flood the relief from sources, and build barriers when different sources are meeting. The resulting set of barriers constitutes a watershed by flooding. A grey-level image may be seen as a topographic relief, where the grey level of a pixel is interpreted as its altitude in the relief. A drop of water falling on a topographic relief flows along a path to finally reach a local minimum. Intuitively, the watershed of a relief corresponds to the limits of the adjacent catchment basins of the drops of water. In image processing, different watershed lines may be computed. In graphs, some may be defined on the nodes, on the edges, or hybrid lines on both nodes and edges. Watersheds may also be defined in the continuous domain [2]. There are also many different algorithms to compute watersheds. For a segmentation purpose, the length of the gradient is interpreted as elevation information.

2. Related Work

The watershed transformation was originally proposed by Beucher and Lantuejoul.They were first to apply the concept of watershed and divide lines to segmentation problems [2]. They used it to segment images of bubbles and SEM metallographic pictures. Unfortunately, this transformation very often leads to an over-segmentation of the image. To overcome this problem, a strategy has been proposed by Meyer and Beucher [3]. This strategy is called marker-controlled segmentation. The watershed transform can be classified as a region-based segmentation approach. The intuitive idea underlying this method comes from geography: it is that of a landscape or topographic relief which is flooded by water, watersheds being the divide lines of the domains of attraction of rain falling over the region [4]. However, our main interest here is in digital images, for which there is even more freedom to define watersheds, since in the discrete case there is no unique definition of the path a drop of water would follow. Many sequential algorithms have been developed to compute watershed transforms [5,6].They can be divided into two classes, one based on the specification of a recursive algorithm by Vincent & Soille [7] and another based on distance functions by Meyer [8]. In the context of parallel implementations there exists a notable tendency for introducing other definitions of the watershed transform, enabling easier parallelization.

3. Watershed Transform

The watershed transformation is a powerful tool for image segmentation. It is the method of choice for image segmentation in the field of mathematical morphology. Generally image segmentation is the process of isolating objects in the image from the background, i.e., partitioning the image into disjoint regions, such that each region is homogeneous with respect to some property, such as grey value or texture [9]. The watershed transform can be classified as a region-based segmentation approach. The intuitive idea underlying this method comes from geography. It is that of a landscape or topographic relief which is flooded by water, watersheds being the divide lines of the domains of attraction of rain falling over the region [10]. This approach is applied as follows; first we define the properties which will be used to mark the objects. These markers are called object markers. The same is done for the background, i.e., for portions of the image in which we are sure there is no pixel belonging to any object. These markers constitute the background markers. The marked image called gradient image.
The gradient image is modified in order to keep only the most significant contours in the areas of interest between the markers. This gradient

modification consists in changing the homotopy of the function. Then, we perform the final contour search on the modified gradient image by using the watershed transformation. The gradient image is often used in the watershed transformation, because the main criterion of the segmentation is the homogeneity of the grey values of the objects present in the image. But, when other criteria are relevant, other functions can be used. In particular, when the segmentation is based on the shape of the objects, the distance function is very helpful. Let us imagine the surface of this relief being immersed in still water, with holes created in local minima is shown in Figure 1 (a). Water fills up the dark areas “the basins” starting at these local minima. Where waters coming from different basins meet we will build dams. When the water level has reached the highest peak in the landscape, the process is stopped. As a result, the landscape is partitioned into regions or basins separated by dams, called watershed lines in Figure 1 (b) or simply watersheds.

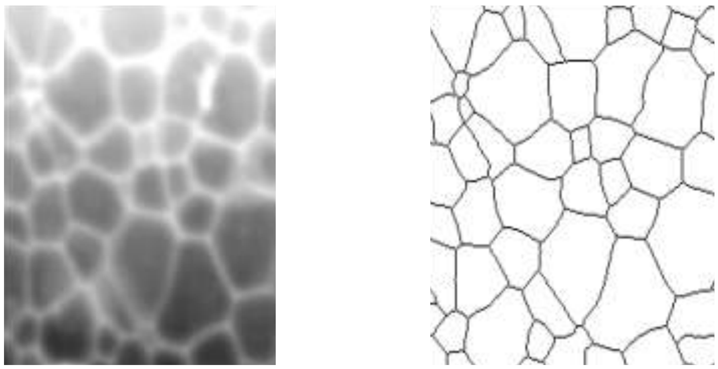


Figure 1. (a) Immersed water image. (b) Watershed lines of immersed water.

3.1 Watershed Transform Definition

The algorithm works on a gray scale image. During the successive flooding of the grey value relief, watersheds with adjacent catchment basins are constructed. This flooding process is performed on the gradient image, i.e. the basins should emerge along the edges. Normally this will lead to an over-segmentation of the image, especially for noisy image material, e.g. medical CT data. A set of markers, pixels where the flooding shall start, are chosen. Each is given a different label. The neighboring pixels of each marked area are inserted into a priority queue with a priority level corresponding to the gray level of the pixel. The pixel with the highest priority level is extracted from the priority queue. If the neighbors of the extracted pixel that have already been labeled all have the same label, then the pixel is labeled with their label. All non-marked neighbors that are not yet in the priority queue are put into the priority queue. The non-labeled pixels are the watershed lines. Label the regional minima with different colors and Select a pixel p, not colored, not watershed, adjacent to some colored pixels, and having the lowest possible gray level is shown in figure 2. If p is adjacent to exactly one color then label p with this color. If p is adjacent to more than one color then label p as watershed. Let (V, E) be a (undirected) graph and let X be a subset of V. We define a point x ($x \in X$) as a W-destructible for if X is x adjacent exactly one connected component of X. We consider the image as a graph. The pixels are the vertices. The edges come from the four neighbors of pixels.

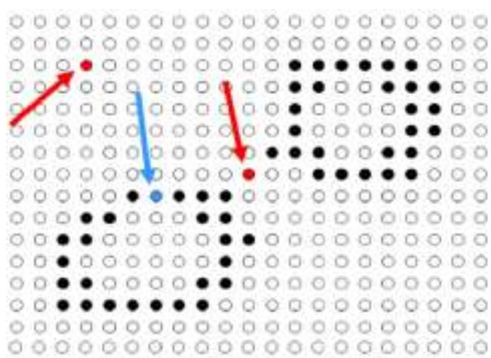


Figure 2. W-destructible points [6]

Let X and Y be two subsets of V. We say that Y is a W-thinning of X if Y may be obtained from X by iteratively removing W-destructible points. Let X and Y be subsets of V. We say that Y is a watershed of X if Y is a W-thinning of X and if there is no W-destructible point for Y. Let F and F` be in F (V). We say that F` is a thinning of F if F` may be obtained from F by iteratively lowering destructible points (by 1). Let F and F` be in F (V). We say that F’ is a watershed of F if F` is a thinning of F and if there is no destructible point for F`.

4. Implementation and Performance analysis

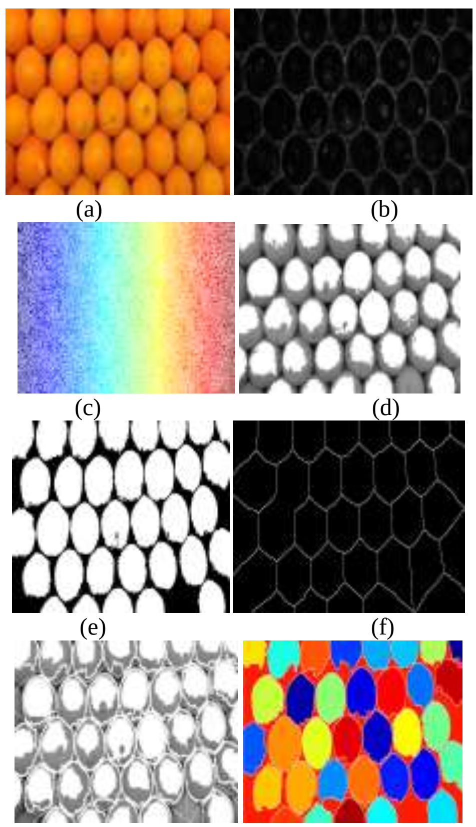
There are few steps involved in proposed technique. For the counting of object in image using Marker-controlled watershed transforms following steps are used:

i. Input image is converted to grayscale image to remove any color information of image.
ii. Compute the segmentation function in the image; mark the dark regions of objects trying to segment.
iii. Mark the foreground objects using morphological techniques called opening –by-reconstruction and closing by reconstruction to clean up the image to obtain the good foreground marks.
iv. Compute the background marks of the image. For the background marks use the threshold operation and darks the pixels that are not part of any object.
v. After the background marks by using the distance watershed transform calculate the boundary of object and watershed rigid lines.
vi. Superimpose the foreground markers, background markers and segmented object boundary on the original image.
vii. Using label matrix label marks obtained in previous step to obtain the color watershed image.
viii. Convert the label watershed transform image into binary.
ix. Find out the boundaries of the objects in binary image.
x. At last count the number of bounded regions in the image to find out number of objects in image.

4.1 Performance analysis

We tested our proposed algorithm for the counting of objects using marked controlled watershed on two different sized images. First image size is of 445x438 resolutions and second one is of 393x298 resolutions. For the accuracy point of view the actual number of objects counted in image one is 38 and in second image is 29. And our proposed algorithm has found 37 objects in first image and 29 in second image. So the accuracy of our proposed algorithm for counting objects in image is quite near to 100 % .The simulation results obtained using our algorithm are as follows:-

(i) Image of size 445x438



(a) (b) (c) (d) (e) (f) (g) (h)

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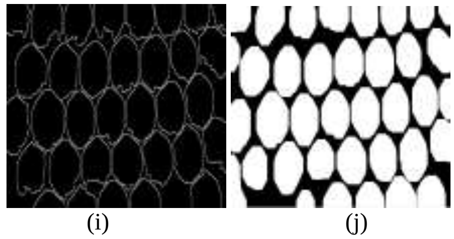

Figure 3. Object count using mark controlled -watershed transform (a) original image (b)Sobel Edge detector (c)Gradient magnitude (d)foreground marks (e)Background mark (f)Watershed lines (g)Watershed lines superimposed image(h)Color watershed label matrices(i)Binary conversion of color watershed (j)Object found.

(ii) Image of size 393x298

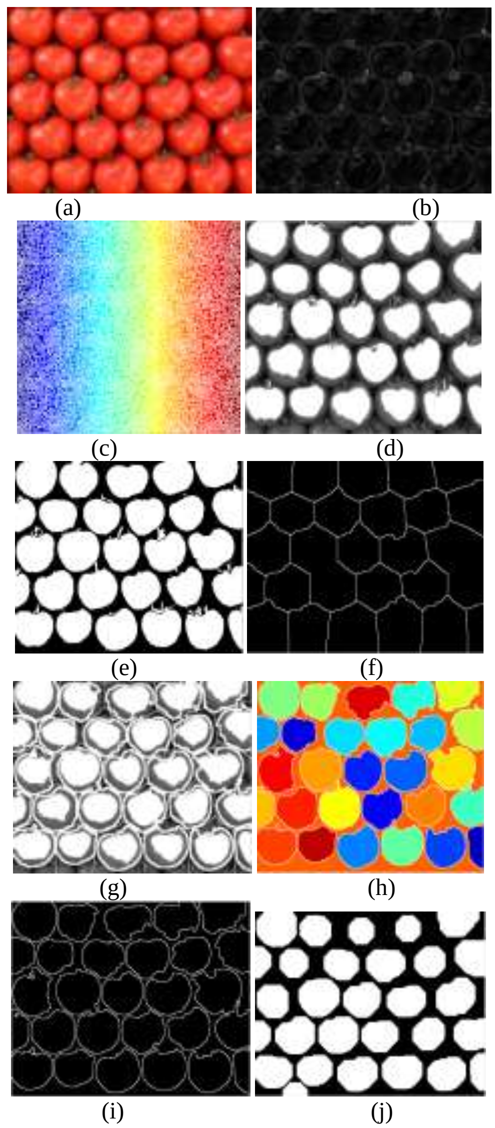

Figure 4. Object count using mark controlled -watershed transform (a) original image (b)Sobel Edge detector (c)Gradient magnitude (d)foreground marks (e)Background mark (f)Watershed lines (g)Watershed lines superimposed image(h)Color watershed label matrices (i)Binary conversion of color watershed (j)Object found.

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Conclusion

In this paper, the new algorithm for counting objects using marker controlled watershed transform is presented. The watershed transform provides closed contours by construction. When computing the watershed there is good match between the contours which undoubtedly appear in the image and divide lines of the gradient watershed, even when it is over segmented. The proposed technique that has been used for separating and counting the objects works accurately.

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