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Marker Controlled Image Segmentation for Detecting Adjacent Objects Based on Watershed Transform

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Abstract
With the rapid development of computer technology its uses are also increasing in different fields of life. In the last decade image processing is immerged as one of the major area of research. The image segmentation is one of the important fields of image processing and computer vision. Image segmentation deals with segregating the different objects or regions of an image. Segmentation accuracy determines the success or failure of computerized analysis procedure. Segmentation using watershed transformation is a process for analyzing a gray scale image. Adjacency of object is a great issue in analyzing such images. This paper presents a robust procedure for detecting adjacency of hard piece of earth's surface based on marker controlled watershed algorithm. Experimental results presented in this paper are obtained by using MATLAB. Sequences of commands can be saved in a text file, typically using the MATLAB Editor.

Keywords
Markers, Image Processing, Segmentation, Watershed Transform.

I. Introduction

Image segmentation is an essential preliminary step for most subsequent image analysis problems. A region consists of sets of pixels which carry valuable information about an object present in an image. The purpose of image segmentation results are mainly for better analyzing and meaningful understanding of morphological images.

Watershed transform [1-2], is a classical method of image segmentation in mathematical morphology. This method has a geometrical approach and deals with object oriented criteria like- size, shape, contrast, connectivity etc. This method has been applied successfully into some fields like biomedical and sensing image processing [3]. Among the various image segmentation techniques marker controlled watershed transform is a powerful approach [4-5]. The procedure of marker controlled watershed segmentation is familiar to basic watershed segmentation [6, 8], only the difference is that we start region growing from the given markers instead of local minima [3, 7]. Marker extraction is the most important and challenging phase of the whole process. Due to good localization performance of detected markers, the contour of separated objects can be extracted by the watershed transform based on detected markers.

In order to give a better explanation of the overall process the paper is divided in the following segments. In section II, previous work is discussed, section III, introduces watershed, and marker controlled watershed transform and proposed algorithm procedure briefly. Section IV, describes implementation results and discussions. Conclusion is given in section V.

II. Background and Preliminary

The idea has been introduced in 1979 by S. Beucher and C. Lantuéjoul. It consists in placing a water source 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. By taking this concept several works has been done in various research fields like biomedical where medical images are segmented, segmenting low contrast images etc. The main idea behind this technique is to segmentation of images. We have tried to use this concept in a new dimension by detecting the adjacency of objects in a geological image. As an example we have chosen hard piece of earth of different size and shape. Adjacency detection of such geological images is a major concerning problem in respect of the vision of the computer.

III. Approach

A. Watersheds

Watersheds are the ridge that divides areas drained by different river systems. Catchment basins are the geographical area draining into a river or reservoir. The watershed transform applies these ideas in gray-scale image processing to solve various problems in image segmentation. The basic view of a watershed can be a landscape of a lake. Some dams are there in the lake and catchment basins are filled up with water starting at each local minimum. As the water continues to rise, it will eventually overflow from one catchment basin to another like from CB1 to CB2 and so on to CB3 as illustrates in figure 1 where CB is catchment basin.

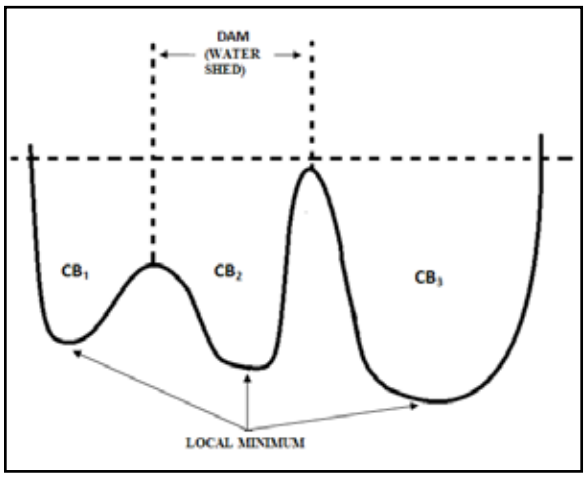

Fig. 1: Watershed Transforms Ingress Process

If water continues to rise only the top part of the catchment basins will be seen. This process is continued until the maximum level of flooding that is highest intensity value in the image is reached. The final dams correspond to the watershed lines will be the desired segmentation result. The watershed principle in image processing is done by finding out the coordinate of the local minima points in the image.

Let CBm refers to the catchment basin points associated with local minima point of a region. It is represented by Z[n]

A[n] = [(x, y) | I (x, y)]

Where,

A[n] is the coordinate of the point in I (I, j)

The no of points lying under the water is needed to be so that the marker to be used will be in black colors for the coordinates A[n] which are below the level I (i, j) = n and the bother points will be in white color.

Let C_nB_m represent the coordinates related to catchment basin CBm which are water field at level n

Thus $C_nB_m = CB_m \cap A[n]$

We can interpret that C[n] refers to union of filling water at all the points of catchment basins at level n. This value is given by

$C[n] = U^{z}_{m} = 1\ C_nB_m$

B. Marker Controlled Watershed Transformation

In the previous section we have discussed the concept of watershed. Usage of watershed in analyzing an image generally leads to oversegmentation of image .The concept of markers is a good approach to control oversegmentation. The markers are connected component of an image. There are internal markers and external markers where internal markers are associated with object of interest and external markers are associated with the background. Marker selection can range from simple procedures based on intensity values and connectivity. The main motive of using markers is marker brings a priori knowledge to bear on the segmentation problem. The following sections will reveal the proposed algorithm, implementation result and discussion followed by the conclusion.

C. Proposed Algorithm

The marker controlled watershed transform is mainly for the problems where adjacent objects are there in an image and we have to separate them using image processing operations. This approach deals with catchment basins and watershed ridge lines in an image by assuming it as a surface where light pixels are low. In the initial step we have to convert a 3D color image into gray scale and compute the gradient magnitude as the segmentation function where gradient is highest at the borders of the object and generally low inside the object. We will then use the internal marker to distinguish the foreground of adjacent objects. The background of the image will then be segregated from the foreground objects using the external markers. Finally we will aggregate the computed result of the watershed transform and examine the final image. The detailed algorithm is the following:

STEP 1: Transfigure the original image in to grayscale.
STEP 2: Estimate the segmentation function.
STEP 3: Enumerate internal markers.
STEP 4: Enumerate the external markers.
STEP 5: Estimate watershed transform and Examine the final result.

IV. Implementation Result

A. Example 1

Fig. 2: Original Image

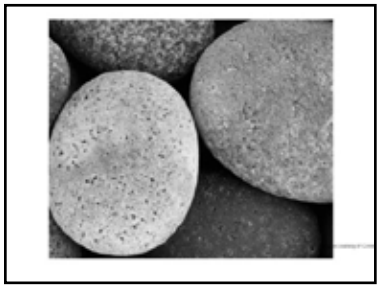

Fig. 3: Transfigure the Original Image in to Grayscale

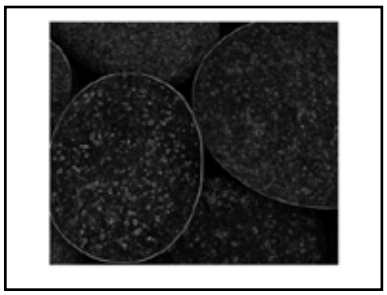

Fig. 4: Estimation of the Segmentation Function

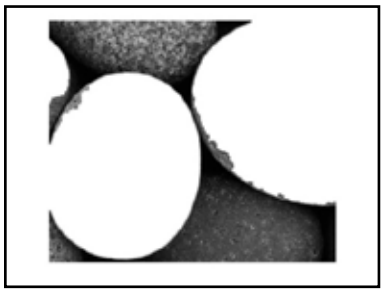

Fig. 5: Enumeration of Internal Markers

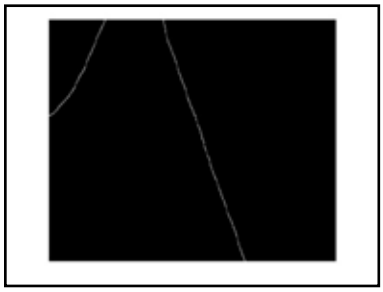

Fig. 6: Watershed Ridge Lines with Enumeration of External Markers

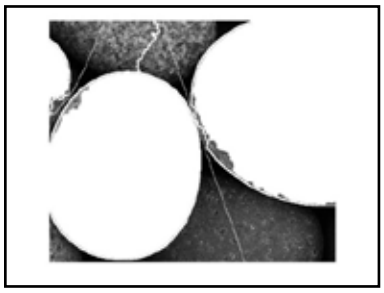

Fig. 7: Object Boundaries and Markers

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B. Example 2

Fig. 8: Original image

Fig. 9: Transfigure the Original Image into Grayscale

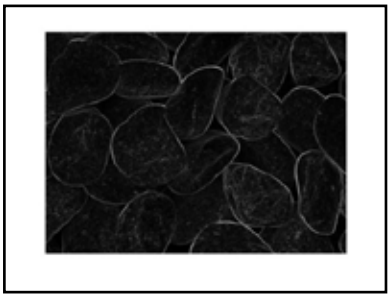

Fig. 10: Estimation of the Segmentation Function

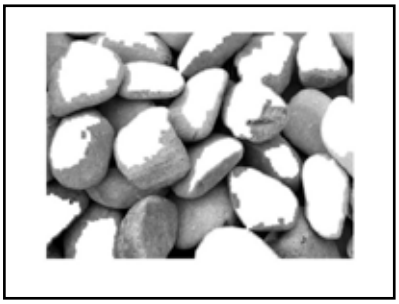

Fig. 11: Enumeration of Internal Markers

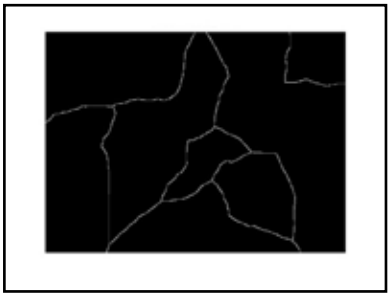

Fig. 12: Watershed Ridge Lines with Enumeration of External Markers

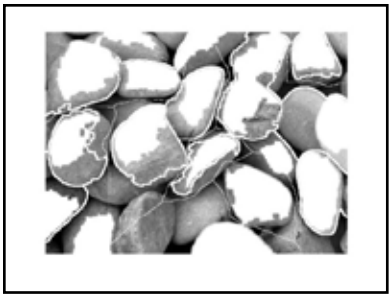

Fig. 13: Object Boundaries and Markers

C. Example 3

Fig. 14: Original Image

Fig. 15: Transfigure the Original Image into Grayscale

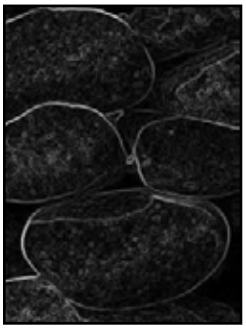

Fig. 16: Estimation of the segmentation Function

Fig. 17: Enumeration of Internal Markers

Fig. 18: Watershed Ridge Lines with Enumeration of External Markers

Fig. 19: Object Boundaries and Markers

V. Conclusions

This paper deals with the problems of image segmentation and it presents a robust procedure for detecting adjacency of hard piece of earth's surface. The motivation behind the image segmentation procedure should be the identification of segment of images according to the characteristics of image like, image color, shape of objects etc along with initialization of the markers i.e. catchment basins. One of the simplest image segmentation procedures is stated here with marker based watershed transform method with satisfactory results. The system will examined only one image at a time. This system can be very helpful for the segmentation of the images to detect the adjacency of objects which are essential in different fields of life.

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