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An Approach To Reduce Oversegmentation In Watershed Ridge Line Observation

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ABSTRACT

This research article presents an effective approach of digital image segmentation with watershed algorithm for reducing over segmentation problem. The implementation is actually intended for digital color image processing. In mathematical morphology, the watershed algorithm is a tool for segmentation of a query image in its original version. The proposed approach is tested on two real life images for getting the desired results.

Keywords : Image segmentation, watershed algorithm.

1 INTRODUCTION

In digital image processing, image segmentation is widely used in every field [1], [2], [3], [4], [5], [6], [7], [8], [9] such as medical imaging, radar imaging, remote sensing imaging, traffic imaging etc. Image segmentation and its performance evolution are very important problems in computer vision. The aim of image segmentation is to cluster pixels into salient image regions for image analysis [5], [6], [7], [8]. But often the image segmentation results suffer from over segmentation [10], [11], [12], [13], [14], [15], [16]. Over segmentation is the process by which the image being small segments. They are generally uniform in size and commonly referred to as super pixels. Over segmentation causes very much difficulty in image study and analysis. To overcome this problem of over segmentation, an effective approach is proposed in this research article with watershed algorithm [17], [18], [19], [20], [21], [22], [23], [24], [25] using gradients and smoothing of the gradient image [5], [6], [20], [21] using spatial low pass linear filter. A Gaussian 7x7 mask is applied for image smoothing [5], [6], [26], [27], [28] purpose and watershed algorithm is applied on the gradient image after smoothing operation for generating the final segmented image with lesser over segmentation for image analysis. The performance of proposed methodology by comparing it with conservative watershed algorithm is also evaluated in this paper.

This paper is divided into various sections. Section 2 introduces a brief description on Gaussian smoothing. Watershed algorithm and its mathematical formulations are discussed in section 3. Section 4 presents the proposed scheme or approach. The experimental results are discussed in section 5 and finally conclusion is discussed in section 6.

2 GAUSSIAN SMOOTHING

The Gaussian smoothing operator is a spatial low pass linear filter that is used to `blur' images and remove detail and noise. The idea of Gaussian smoothing is to use this 2-D distribution as a `point-spread' function, and this is achieved by convolution. Since the image is stored as a collection of discrete pixels we need to produce a discrete approximation to the Gaussian function before we can perform the convolution. The degree of smoothing is determined by the standard deviation of the Gaussian. It is obvious that larger standard deviation Gaussians require larger convolution kernels. In below a Gaussian 7x7 mask which is used for smoothing purpose of the gradient image is shown.

1	2	3	4	3	2	1
2	3	4	7	4	3	2
3	4	16	26	16	4	3
4	7	26	41	26	7	4
3	4	16	26	16	4	3
2	3	4	7	4	3	2
1	2	3	4	3	2	1

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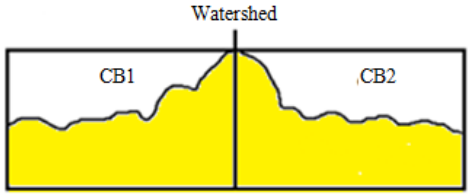
Fig 1. Gaussian 7x7 mask.

3 WATERSHED ALGORITHM



Watershed transform is the technique which is commonly used in image segmentation. Watershed transform or Watershed Algorithm is based on grey-scale morphology. It is classified as a region-based segmentation approach. When a landscape or topographic relief is flooded with water, the divide lines of the domains of rain falling over the regions forms the watersheds. An alternative approach is to imagine the landscape being immersed in a lake in which holes are pierced in the local minima is called the catchment basin (CB). Water will be filled up at these starting local minima and at points where water coming from different basins would meet and dams will be built. When the water level reaches 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 ridge lines or simply watersheds. The mathematical formulation of watershed algorithm is sated below.

Assume, M_i where $i= 1$ to n be the set of coordinates points in the regional minima (catchment basins), of the image $P(x,y)$ and $C(M_i)$ be the coordinates points of catchment basins associated with the regional minima M_i

$$Tn = \{(s,t) \mid P(s,t) < n\} \quad (1)$$

Where,

$T[n]$ = set of points in $P(x,y)$ which are lying below the plane $p(x,y) = n$

min, max = minimum or maximum gray level value.

n = stage of flooding varies from min + 1 to max + 1

Let $C_n(M_1)$ be the set of points in the catchment basin associated with M_1 that are flooded at stage

$$Cn(M1) = \cap \{C(M1), T[n]\} \quad (2)$$

Where,

Fig 2. Watershed segmentation-local minima of gray level yield catchment basins, local maxima define the watershed lines.

$$Cn(M_i) = \begin{cases} 1, & if\ (x,y) \in C(M_i) and (x,y) \in T[n] \\ 0, & otherwise \end{cases} \quad (3)$$

$C[n]$ is the union of flooded catchment basin portions at the stage n.

Where,

$$C[n] = Cn(m1) \cup Cn(m2) \ldots\ldots Cn(mR) \quad (4)$$

$$C[max + 1] = C(m1) \cup C(m2) \ldots\ldots C(mR) \quad (5)$$

If the algorithm keeps on increasing flooding level then $C_n(M_i)$ and $T[n]$ will either remain constant or increase. Algorithm initializes $C[min + 1] = T[min + 1]$, and then precedes recursively by assuming that at step n $C\ [n - 1]$ has been constructed.

Let, G is a set of connected components in $T[n]$ and for each connected component $g \in G[n]$, there possibilities will arise.

1. $g \cap C[n - 1]$ is empty.

2. $g \cap C[n - 1]$ contains one connected component of $C[n - 1]$.

3. $g \cap C[n - 1]$ contains more than one connected component of $C[n - 1]$.

4 APPROACH

A very promising approach is tried for obtaining better result in image segmentation and reducing over segmentation using morphological approach. The tool that is used for image segmentation is watershed algorithm. A Gaussian spatial linear low pass filter is used in intermediate stage of proposed approach for smoothing of the gradient image. The flowchart shown in figure 2 describes the proposed approach. In the proposed approach, firstly a color image is chosen, and converted to grayscale or black and white image. The next step is to generate the gradient magnitude from the gray scale image. The Sobel high pass filter is used for that purpose and

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finally watershed algorithm has been applied to the smoothed image to get the final segmented image or the desired result.

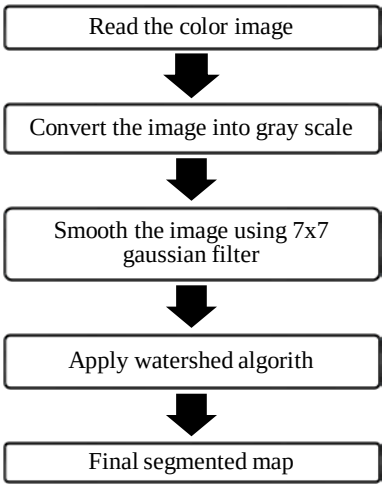

Fig 3. Flowchart of the proposed approach.

5 EXPERIMENTAL RESULTS

The proposed methodology is applied on two well known images of Lena and Laure of dimensions of 512 x 512, and 256 x 256 accordingly. The performance of proposed methodology by comparing it with conservative watershed algorithm has been evaluated. The original images are shown in figure 4 and 7 respectively. Final segmented images acquired by conservative watershed algorithm are shown in 5 and 8, final segmented images acquired by proposed approach are shown in figure 6 and 9 respectively. It has been observed from the segmented images acquired by applying conservative watershed algorithm that they are extremely over segmented. The use of proposed approach has achieved the objective of reducing the problem of over-segmentation when applied to images. The Entropy, PSNR and MSE of the final segmented images applying conservative watershed algorithm and by applying proposed approach have been calculated and the values have been shown in the table 1.

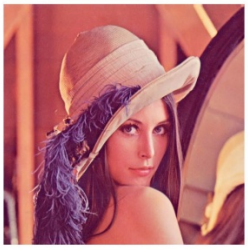

Fig 4. Original image of Lena.

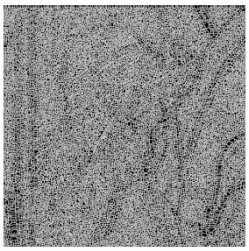

Fig 5. Segmented image of Lena by applying conservative watershed algorithm.

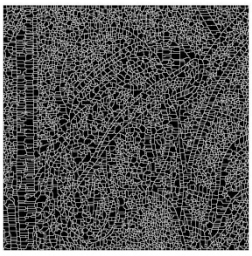

Fig 6. Segmented image of Lena by applying proposed approach.

Fig 7. Original image of Laure.

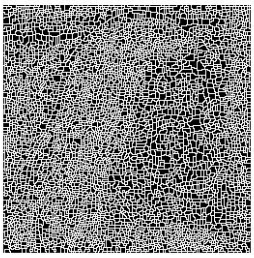

Fig 8. Segmented image of Laure by applying conservative watershed algorithm.

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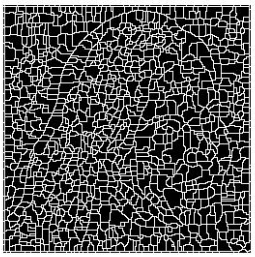

Fig 9. Segmented image of Laure by applying proposed approach.

Table 1

Statistical Measurement

Image	Entropy	PSNR	MSE
Lena with conservative watershed algorithm	3.1290	7.5084	1.1541e+004
Lena with Proposed approach	3.1857	7.6580	1.1150e+004
Laure with conservative watershed algorithm	2.4822	8.4528	9.2855e+003
Laure with Proposed approach	2.5585	9.4213	7.4293e+003

6 CONCLUSION

The watershed algorithm is an image segmentation tool in mathematical morphology, which produces over segmentation if directly applied on gradient images. But this drawback can be overcome by smoothing the gradient image with the help of spatial linear low pass filter. A gaussian 7x7 mask is used for the smoothing purpose followed by applying watershed algorithm to generate the final segmented image. It can be observed from the final resultant or segmented images that the technique of reducing the over segmentation is a promising approach.

DEDICATION

One of the others (Dibyendu Ghoshal) dedicates the entire study to the loveliest and loving memory of his only one and younger sister Kumari Sumita Ghoshal who herself was a gem of the scholars, a symbol of wisdom and art, peerless beauty and simplicity, unfathomable knowledge and generosity.

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