

# A Morphological Approach of Image Segmentation Using Stochastic Gradients and Marker Controlled Watershed Transform

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**Abstract**— In this research paper a useful approach for digital color image segmentation is performed by combining stochastic gradient filter and marker controlled watershed transform. If only watershed algorithm be used for noisy image segmentation purpose, the over segmentation problem arise. This approach is based on the concept of stochastic gradient filter for generating gradient image from noisy images and marker controlled watershed transform for the reduction of over segmentation problem. The experimental results confirm the effectiveness of the proposed approach to get the high accuracy image segmentation.

**Index Terms**— Stochastic gradients, over- segmentation, markers, watershed algorithm.

## 1 INTRODUCTION

IN digital image processing, image segmentation [1], [2], [3], [4], [5], [6], [7] refers to dividing digital images into multiple regions or objects. The region or objects consists of a set of pixels enjoying similar characteristics such as color, intensity or texture. Segmentation of images is very much essential for most sub sequent image analysis tasks such as image description, recognition, image visualization, etc. There are many approaches to image segmentation such as classifications, edges or regions [5].

Mathematical morphology [8], [9], [10] is a powerful tool for image segmentation. In mathematical morphology watershed algorithm is [11], [12], [13], [14], [15], [16] a tool for image segmentation. This algorithm also has some drawbacks. Watershed transform is very sensitive to noise. It refers to a situation where an original image gets corrupted by certain additive and adaptive noises. As an example, the images of the stellar objects [4], [5], [6] are acquired by satellites. The space trap already set off for long voyage, Hubble space

telescope are most often found to be corrupted by different noises [7], [24]. Watershed transform is unable to produce good segmentation results if applied in those types of noisy images. Use of watershed transform produces over segmentation [14]. When the watershed transform is directly applied in to a gradient image, the result of the watershed transform of the original image contains a myriad of small regions or segments [25], [26], [27] which produces an over segmented image. Again, if the image objects are of irregular shape and they are overlapping or touching. Watershed produces another problem [14] that is the watersheds constructed may not agree or coincide with the actual image object junctions as only the binary image is used and information contained in the gray scale image is not utilized.

In this research paper an effective approach based on mathematical morphology is presented. With the combination of stochastic gradients and marker controlled watershed transform. All though a large number of research papers [1], [2], [3], [4], [5], [6], [7], [8], [9], [10], [11], [12], [13] are found in various journals, no study based on the stochastic gradient in marker controlled watershed transform is available in published or online literature. This approach is very effective for addressing types of problems mentioned above. Using this method, we will have a decrease in the amount of noise and also the small details will be removed from image and only large objects will remain. Comparative study is also included

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in this work by comparing the results with proposed approach with conventional watershed segmentation approach.

This paper is divided into a choice of sections. In section 2, stochastic gradient is publicized. Section 3 introduces a brief description on marker controlled watershed algorithm. Section 4 describes the proposed approach. The experimental results are discussed in section 5 and the conclusion is presented in section 6.

## 2 STOCHASTIC GRADIENT

The gradient masks of standard high pass spatial filters perform poorly in noisy images. A better alternative is to design some masks, which take into the presence of noise in a controlled manner. The stochastic gradient operator can be obtained using definitions in (1).

$$g_1(m, n) \triangleq u_f(m, n - 1) - u_b(m, n + 1) \quad (1)$$

Stochastic gradient operators with different mask that is used in this work is shown in figure.

|       |       |   |        |        |
|-------|-------|---|--------|--------|
| 0.802 | 0.836 | 0 | -0.836 | -0.802 |
| 0.845 | 0.897 | 0 | -0.897 | -0.845 |
| 0.870 | 1.00  | 0 | -1.00  | -0.870 |
| 0.845 | 0.897 | 0 | -0.897 | -0.845 |
| 0.802 | 0.836 | 0 | -0.836 | -0.802 |

Fig 1. 5x5 Stochastic gradient mask, SNR=1.

## 3 MARKER CONTROLLED WATERSHED TRANSFORM

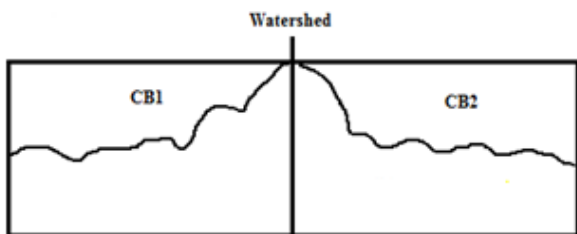


Fig 2. Watershed segmentation-local minima of gray level yield catchment basins, local maxima define the watershed lines.

Watershed algorithm is a tool for morphological image segmentation. A gray scale image can be interpreted as the topographic image of landscape. This is accomplished with the image intensity as an altitude. Using the features of these images, the technique of digital image processing called

Watershed Transform. It consists in placing a water source in each regional minimum or catchment basins (CB), to flood the relief from sources, and build barriers when different sources are meeting. The resulting set of barriers constitutes a watershed by flooding, i.e., the set of pixels along which the gray levels changes sharply gives rise to a watershed edge. Though it is a very good method for image segmentation, but this technique suffers from over segmentation problem. An approach used to control over segmentation is based on the concept of controlled marker. The concept of markers is a good approach to control over segmentation. 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. This is a very useful technique for improvisation of watershed transform to overcome the over segmentation problem. In this technique, the set of the catchment basins of the grayscale image function  $f$  with values in  $[l_{min}, l_{max}]$  is equal to the set  $Y_{l_{max}}$  obtained after the following recursion:  $Y_{l_{min}} = T_{l_{min}}(f)$ , where  $T_l$  is the threshold set at level  $l$

$$Y_{l+1} = \cup \{MIN_{l+1}, IZ_{T_{l+1}(f)}\}, l_{min} \leq l \leq l_{max} \quad (2)$$

Where,  $MIN_l$  is the union of all regional minima at altitude  $l$

And

$$IZ_A(b) = U_{x=y}^m IZ_A(B_x) \quad (3)$$

Where,  $IZ_A(B_j) = \{P \in A \mid \forall v_k \in [1, m] \{x\}: d_A(P, B_k) < d_A(P, B_k)\}$  (4)

$$D_A(a, b) = \min_{b \in B} d_A(a, b) \quad (5)$$

$d_A(a, b)$  represents the geodesic distance between  $a$  and  $b$  within  $A$ . Let us note in the set of markers we can define a function  $r$  as:

$$r(p) = \begin{cases} l_{min-1} & \text{if } p \in M \\ f(p) & \text{otherwise} \end{cases} \quad (7)$$

Where  $p$  represents pixel coordinates and  $l_{min-1}$  denotes a new value dedicated for initial markers. Now the recursion definition will be:

$$\begin{aligned} Y_{l_{min-1}} &= T_{l_{min-1}}(r) \\ Y_{l+1} &= IZ_{T_{l+1}(r)}(x), l_{min} \leq l \leq l_{max} \end{aligned} \quad (8)$$

## 4 PROPOSED APPROACH

Three real life digital color image is chosen and noise is added on them to show the ability of this algorithm for image segmentation. The results indicate that this algorithm has a high performance in detecting object edges and reducing over segmentation. The flowchart of the proposed approach is stated below (Figure 3). This approach is based on the concept of stochastic gradient filter generating gradient image from noisy images and marker controlled watershed transform for the reduction of over segmentation. In an image marker is a connected component. There are two types of markers in an image, internal markers and external markers. The set of internal markers are associated with objects of interest or with the foreground objects and set of external markers are associated with the background. These markers are used to modify the gradient image which is obtained by applying special edge detecting filters. In this research a 5x5 stochastic gradient filter (figure 1) has been used instead of standard high pass filters like, Sobel, Canny, Roberts, etc, as stochastic gradient filters [15] have been found to be efficient reducing various types of noises in a controlled manner. In first step of present approach, noisy color images are chosen and accordingly converted into a gray scale image in second step. In third step the gradient image is computed using stochastic gradient filter of 5x5 mask with SR=1 (Figure 1). Next step of present marker controlled watershed transform is applied. It computes the foreground objects using internal markers with the concept of morphological structuring element. Disk structuring element has been applied in present study. The back ground objects are computed using external markers and the final segmented map is obtained in the final step. In final segmented images are shown in figure 6.

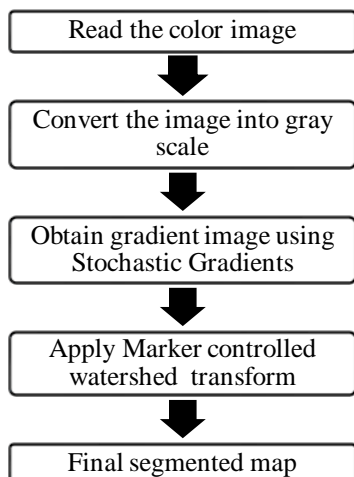


Figure 3: Flowchart of proposed approach.

## 5 EXPERIMENTAL RESULTS AND DISCUSSION

The results obtained by the application of proposed approach on three real life images of Flower, Stones and fruits. For experimental purpose, noises are added on these images first and those noisy images are shown in Figure 4(a), 4(b) and 4(c) respectively. For comparative study purpose the segmented results of conventional watershed approach is included where, the gradient images are generated using Sobel high pass filter. Then, watershed algorithm is directly applied on the gradient images to get the final segmented result. The segmented images with conventional approach are shown in figure 5(a), 5(b) and 5(c) respectively. The final segmented results with proposed approach are shown in figure 6(a), 6(b) and 6(c) respectively.

From the results of conventional watershed segmentation approach, it is very hard to extract any information as the images are extremely over segmented and noisy. But, it is observed from the segmented images using proposed approach that, the edges of the foreground objects are very sharp, prominent and almost accurate in human vision. From the comparative study analysis, this work that this approach is exhibits a high performance in image segmentation for image study, analysis and object edge detection. The statistical measurements are also included and shown in table 1. They are analyzed in respective of Entropy, peak signal to noise ratio (PSNR) and mean square error (MSE). Experimental results presented in this paper are obtained by using MATLAB.

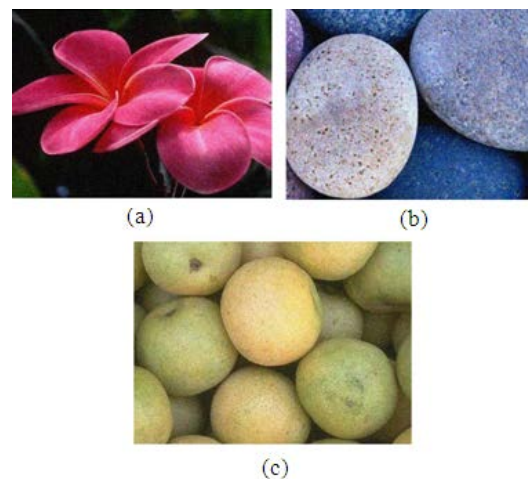


Fig 4. Original noisy Images, (a) Flower, (b) Stones and (c) Fruits.

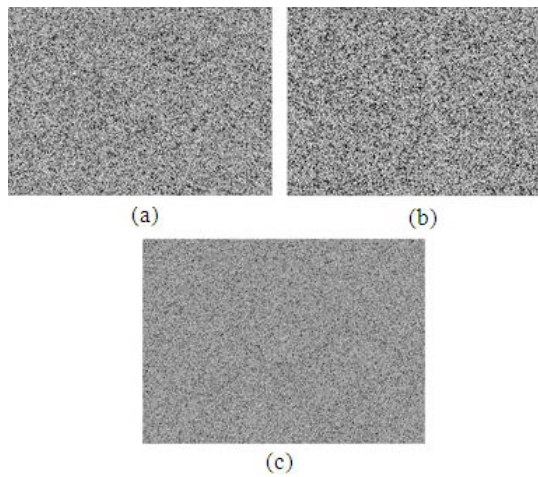


Fig 5. Segmented images using conventional watershed approach, (a) Flower, (b) Stones and (c) Fruits.

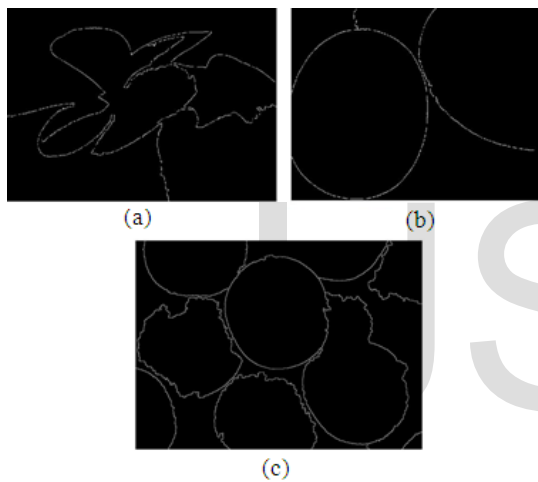


Fig 6. Segmented images using proposed approach, (a) Flower, (b) Stones and (c) Fruits.

|        |                   |        |        |             |
|--------|-------------------|--------|--------|-------------|
| Fruits | Proposed approach | 1.3998 | 5.8809 | 1.6788e+004 |
|--------|-------------------|--------|--------|-------------|

## 6 CONCLUSION

Watershed algorithm is very sensitive to noise and produce over segmentation. In this research paper an image segmentation approach is proposed to solve these problems by combining stochastic gradient filter and marker controlled watershed transform. Stochastic gradients are very effective for detection of edges in noisy images rather than the standard high pass filters and marker controlled watershed transform is a good solution to overcome the problem of over segmentation. The proposed approach has applied on color images for image segmentation. It is observed from the experimental results obtained in this work that this approach is exhibits a high performance in image segmentation and object edge detection.

## 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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TABLE 1

### STATISTICAL MEASUREMENTS

| IMAGE  | APPROACH USED         | ENTROPY | PSNR    | MSE         |
|--------|-----------------------|---------|---------|-------------|
| Flower | Conventional approach | 3.0454  | 6.2067  | 1.5574e+004 |
| Stones | Conventional approach | 2.9649  | 7.6238  | 1.1238e+004 |
| Fruits | Conventional approach | 3.2620  | 7.2601  | 1.2220e+004 |
| Flower | Proposed approach     | 1.4545  | 11.6227 | 4.4752e+003 |
| Stones | Proposed approach     | 1.3497  | 7.2805  | 1.2163e+004 |

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