Edge embedded Marker based Watershed Method for image segmentation

Khin Lay Mon[1], Mie Mie Thaw[2]
[1)]*Hardware Department, University of Computer Studies, Mandalay, Myanmar*
[2)]*Hardware Department, University of Computer Studies, Mandalay, Myanmar*
**E-mail: khinlaymon.tk@gmail.com, miemiethaw@gmail.com*

Image segmentation has been a significant and difficult task digital image processing. Conflict between generality and objectivity becomes an important issue in image segmentation. Segmentation accuracy determines the success or failure of computerized analysis procedure. Therefore, we propose an automatic segmentation method that is useful for computer vision. The Proposed system are combined the modified Laplacian of Gaussian (LoG) edge detection filter which is used to produce accurate gradient magnitude and Marker Controlled Watershed Transformation. In this paper, firstly, watershed algorithm with Laplacian of Gaussian (LoG) edge detector is used to detect the clear edge map of the input image and produce the image which is less sensitive to noise. Marker-controlled watershed segmentation provides to get the beter segmented image with less over segmentation. Therefore, our proposed method can detect a detailed, accurate and satisfactory segmentation image without any broken edges while overcoming over segmentation problem due to conventional watershed segmentation.

1. Introduction

Image segmentation separates the objects and components of the image [4-6]. Segmentation algorithms are classified on the basis of the segmentation techniques like edge and contour based techniques, region based techniques, threshold selection based image segmentation techniques, etc. All these methods have their own limitations and advantages in terms of suitability, applicability, computer's memory space, transmission time of image data, computational cost and overall performance. The main aim of segmentation is to find certain interested objects which may be depicted in the image. But it is encountered with noise. That means if image contains noisy signals, this result makes an unwanted segmentation and cannot detect the detailed image. Noise is the random variation of brightness or color information which is either due to technology limitation or environmental factor. It produces unpredictable results. Therefore, before performing segmentation on images, it is necessary to remove noise from it. Although various spatial and frequency domain filtering techniques exist, in this paper, Laplacian of Gaussian (LoG) edge detector are used. LoG edge detector is combined with the watershed segmentation to yield good results.

A good number of works has already been carried out on watershed segmentation and applied to solve the problem related to digital image segmentation. These are available in the published or online literature [7-12]. Pinaki Pratim Acharjya, Santanu Santra, Dibyendu Ghoshal presented an improved scheme on morphological image segmentation using the gradients. They introduced the concept of edge detection with gradient and used the system to produce an effective watershed technique for natural images[1].

Pinaki Pratim Acharjya, Dibyendu Ghoshal [12] discussed an improved scheme on morphological image segmentation that is suitable for human visual system. They had shown that watershed segmented image obtained by extended LoG mask appears to be much more clear with sharp and prominent watershed ridges and the number of segmented have been found to much less than conventional filter. Bieniek and Moga [8] present an efficient watershed algorithm based on connected components.

Vincent et al. [11] proposed a famous watershed algorithm called 'immersion algorithm,' which provides an effective and efficient implementation for watershed transform. In order to avoid over segmentation, generally marker controlled watershed technique [7] is followed but the whole process has been found to be a comparatively lengthy process in terms of computation. Therefore, many researchers had to try an efficient technique which may yield larger segmented regions and it can be expected that it would solve for the suppression of over segmentation and it will be also easier for handling by the machine. Other researchers also proposed different methods to avoid the problem of watershed. Therefore, in this paper, this research work is expected and motivated to overcome the over segmentation problem and produce the meaningful result.

In the present study, LoG edge detection operator is used with the watershed algorithm to generate the better segmentation results with less over segmentation. Although the 5x5 LOG filtering kernal proposed by Marr-Hildreth [10] is a default mask, the mask can be extended dimensionally on the basis of the need of the image processing situation. A modified scheme of LoG operator with 7x7 mask is proposed to find an initial edge map and contour of a digital image and produces greater accuracy and lesser over segmentation in edge detection. It has been found from the segmented image that in this case the over segmentation is appreciably less than those obtained by using other edge detecting techniques. It has been already found that the watershed segments are very prominent and the watershed boundaries are also very sharp and this lower scale of over segmentation will enable the computers to process the segmented images more easily and with lower cost.

The structure of this work is the following: Section 2 introduces our proposed scheme of the modified Laplacian of Gaussian detector with 7x7 kernel, the conventional Laplacian of Gaussian and describes the brief procedure of the proposed system. Section 3 presents a brief description of experiment. The results are discussed in section 4 and the detailed steps of the proposed system are also described in this section together. We finish this paper with some concluding remarks with section 5.

2. Proposed Scheme

The Laplacian of Gaussian filter (LoG) plays a very important role in image segmentation. This detector finds edges by looking for zero crossings after filtering f(x, y) with a Laplacian of Gaussian filter. It is a convolution filter that is used to highlight edges of different objects.

In this method, the Gaussian filtering is combined with Laplacian to break down the image where the intensity varies to detect the edges effectively.

0	0	-1	0	0
0	-1	-2	-1	0
-1	-2	16	-2	-1
0	-1	-2	-1	0
0	0	-1	0	0

Fig. 1 A conventional 5x5 mask LoG filter

0	1	4	6	4	1	0
1	8	17	18	17	8	1
4	17	-3	-46	-3	17	4
6	18	-46	-137	-46	18	6
4	17	-3	-46	-3	17	4
1	8	17	18	17	8	1
0	1	4	6	4	1	0

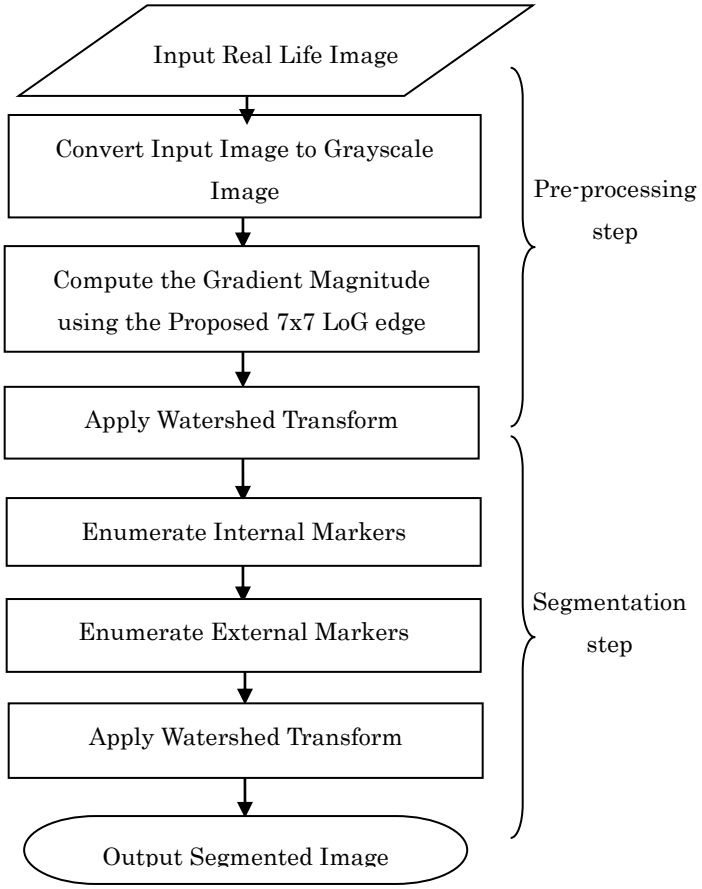
Fig. 2 A modified 7x7 mask LoG filter

The proposed system can be divided into two parts: preprocessing step and segmentation step. In the preprocessing part, 7x7LoG mask has been proposed as shown in figure (2). It has been studied that conventional5x5LoG mask with default standard deviation 0.5 in figure (1) needs to be extended in any arbitrary size for more accurate detection of objects. Therefore, we have tried a new approach for modifying conventional LoG mask. To construct the modified 7x7LoG mask, the LoG function centered zero and approximated with the profile of standard deviation 1.4 in equation (1).

$$\mathrm{LoG}(x,y) = \frac{-1}{\pi\delta^4}\left(1 - \frac{x^2+y^2}{2\delta^2}\right)e^{\frac{x^2+y^2}{2\delta^2}} \quad (1)$$

In this mask, there are two annular regions with positive and negative weights which surround the central pixel. The negative weights are assigned for inner one and the positive weights are

assigned for outer one. The weights are depended on the distance from the center pixel and the approximation of Gaussian standard deviation. The size of optimal mask was found in 7x7 dimensions after calculating the larger number of trails. We have also found that there is no loss of generality if the weights of individual pixel in the mask are changed slightly because of keeping in mind the basic requirement of being isotopic for the construction of mask. The better approximation of gradient magnitudes of gray level image is subsequently computed by using this modified 7x7LoG filter. Therefore, the better approximation of gradient image can avoid extremely over segmented regions. The flowchart of the proposed algorithm is depicted in figure (3).



3. Fig. 3 The flowchart of the Proposed Scheme

4. Experiment

The present study performs mainly two processes: preprocessing step and segmentation step. In preprocessing step, the images which obtained from the real life have been tested to find the gradient image with the proposed LoG filter and subsequently applied watershed as a segmentation function. As the initial stage, a color image from the real life is chosen and read with MATLAB editor using 'imread' function. The next step is converting the color image into grayscale or black and white image by using 'rgb2gray'. Then, the gradient image is resulted from the gray level image with the help of proposed modified mask of LoG. The gradient image can directly apply to watershed segmentation. In segmentation step, watershed algorithm is applied for finding initial segmentation map and the image is analyzed the result (over-segmentation). We can easily see many over-segmented regions that are not suitable in subsequent tasks. To reduce over segmented region, a solution can be achieved by using Marker controlled watershed segmentation. External markers are computed by using opening and reconstruction procedure. As the final step, the internal markers are computed and applied the watershed transform as the final segmentation function and visual the

result. The segmented output is more pleasing without over-segmentation and is also less time complex than other conventional algorithms.

5. Results and Discussion

The focus on this experiment is both for getting better image segmentation result and solving over segmentation problem by using marker controlled watershed segmentation and modified LoG edge detector. The experiments are carried out color images from real life. Figure 5(a) and 6(a) display the original colorful images.

The image is converted to gray level image for processing the subsequent algorithms. In watershed segmentation, a gray level image can be interpreted as the topographic image of landscape. Then, the gray level image has been processed to get the corresponding gradient image by using modified 7x7 LoG mask. The gradient image can be directly applied to watershed segmentation. Figure 5(b) and 6(b) displays the corresponding gradient image that has been observed with the proposed system. After that, the gradient image which obtained by using 5x5 LoG filter mask is segmented with conventional watershed transform .There has found over segmented regions as shown in figure 5(c) and 6(c) respectively. It results an unsuitable final segmented image as shown in figure 5(e) and 6(e). In order to get better result, these over segmented regions are processed with marker-controlled watershed transform. The gradient image by applying 7x7 LoG filter is shown in figure 5(d) and 6(d). The image is passed with marker controlled watershed to get the final segmented image. Figure 5(f) and Figure 6(f) display the acceptable segmented image by using the proposed approach.

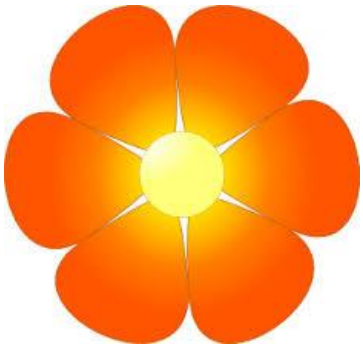


Fig. 5(a) Original color Image

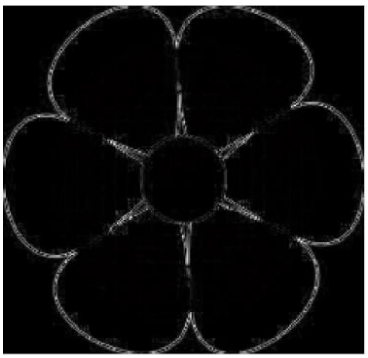


Fig. 5(b) Gradient image using 7x7 LoG filter

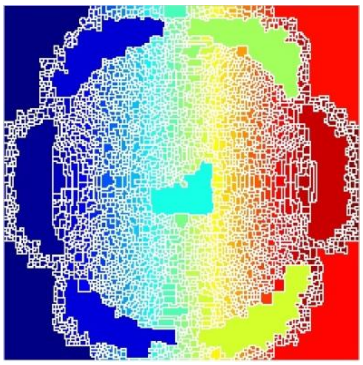


Fig. 5(c) Over segmented image by applying watershed and 5x5 LoG filter

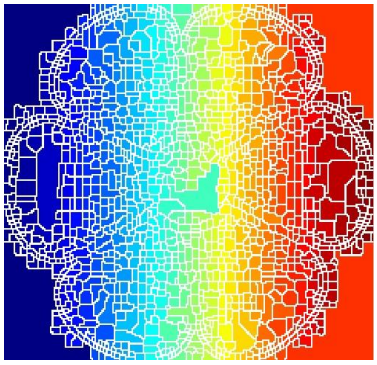


Fig. 5(d) Over segmented image by applying watershed and 7x7 LoG filter

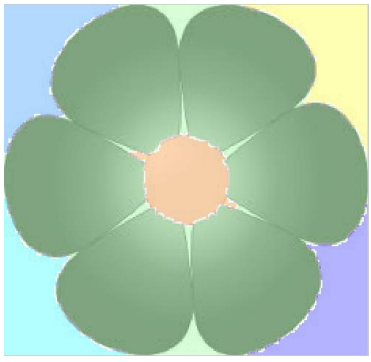


Fig. 5(e) **S**egmented image by applying Marker Controlled watershed and 5x5

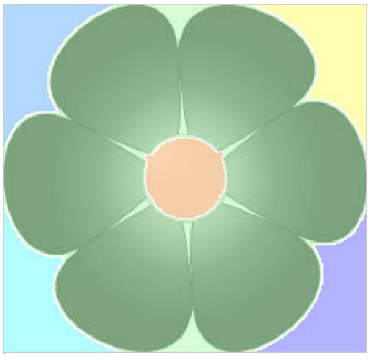


Fig. 5(f) **S**egmented image by applying Marker Controlled watershed and 7x7 LoG filter

We can easily seen by comparing with the segmented images of modified 7x7 LoG mask that

conventional 5x5 Log edge detector have produced pale edges (i.e, the edges in image are not very sharp). Therefore, in practice, these gradient images can affect the segmented images in the next step. On the other hand, we have been found that modified LoG filter can give more enhance gradient images than conventional LoG filter. Thus, it results less over segmented image and gets better final segmented image.

In this case, it has been observed that the edges and boundaries of the images are also seen to be more prominent and clear with better contrast and less over segmented regions. Over segmentation is a very difficult problem in watershed segmentation. However, the proposed filter can be optimized the segmented image by following marker-controlled watershed segmentation.

Fig. 6(a) Original Color Image

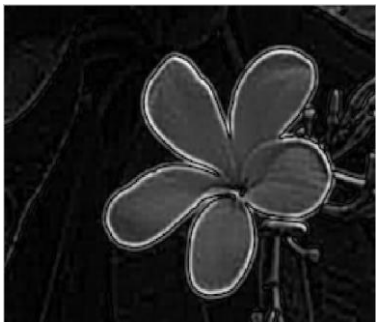


Fig. 6(b) Gradient Image by applying 7x7 LoG filter

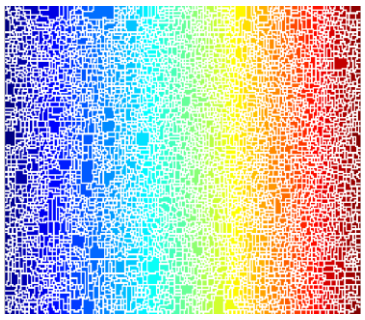


Fig. 6(c) Over Segmented Image by applying watershed and 5x5 LoG filter

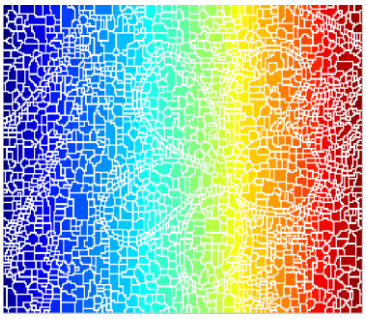


Fig. 6(d) Over Segmented Image by applying watershed and 7x7 LoG filter

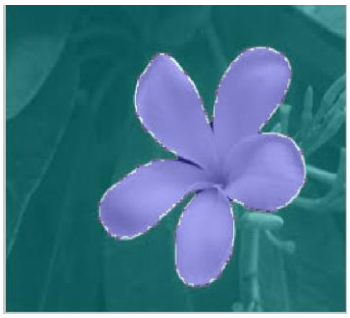


Fig. 6(e) Segmented image by applying Marker Controlled watershed and 5x5 LoG filter

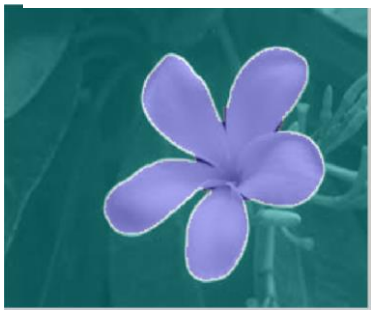


Fig. 6(f) Segmented image by applying Marker Controlled watershed and 7x7 LoG filter

Table1. Entropy of Final Segmented Image

Figure	Entropy of the final segmented Image(5x5 LoG and Marker Controlled Watershed)	Entropy of the final segmented Image(7x7) LoG and Marker Controlled Watershed)
Figure 5(f)	1.3813	1.3567
Figure 6(f)	0.9762	0.9737

The entropies of the final segmented images using marker controlled watershed segmentation through 5x5 LoG filter and the proposed 7x7 LoG filter have been calculated and the values have been shown in the table 1. Experimental results presented in this paper are obtained by using

MATLAB R2010a.

6. Conclusion

Image Segmentation is one of the important fields of image processing and computer vision. The role of image segmentation is to decompose an image into parts that are meaningful with respect to a particular application such as image analysis, image understanding activities, image description and recognition, image visualization and object-based image compression etc. These subsequence steps are highly depend on the segmentation results obtained from previous image segmentation stage. The goal of image segmentation process is to identify the segments of the image according to the characteristics of objects e.g. object shape, image color etc. We have proposed a very simple methodology to control over segmentation for the natural images with marker controlled watershed algorithm. In order to solve the over segmentation problem of traditional watershed technique an improved technique is proposed that uses pre processing methods to reduce the noise of image and adjust the image intensity. The proposed method with LOG filter can make to be better localization when the edges are not very sharp. The presented method has been found to yield better output in term of image quality, clarity and sharpness. The proposed system can perform the input image with the less number of segments and can give the meaningful and acceptable results of image segmentation. The proposed method with marker controlled watershed overcomes over segmentation problem more than conventional watershed transform. This system can be very helpful for image segmentation to detect an accurate image clearer. Experimental results presented in this paper are obtained by using MATLAB R2010a.

Acknowledgments

We would like to thank my supervisor Dr. Mie Mie Thaw, Assistant Lecturer at University of Computer Studies, Mandalay because of her encourage to me.

References

[1] Pinaki Pratim Acharjya, Santanu Santra, Dibyendu Ghoshal "Improved Scheme on Morphological Image Segmentation Using the Gradients" IJACSA International Journal of Advanced Computer Science and Applications, vol 4, No.2, 2013.

[2] Usha Mittal, Sanyam Anand, "Effect of Morphological Filters on Medical Image Segmentation using Improved Watershed Segmentation" ISSN.Vol 4, No.6 Jun,2013.

[3] Ms.K.Kavi Niranjana, Ms.M.Kalpana Devi, Ms.L.Mary, International Journal of Engineering Research & Technology (IJERT),Vol. 1 Issue 7, September,2012" Image Segmentation Using MCWS Algorithm".

[4] A.K.Jain, Fundamentals of digital image processing, Second Edition, Prentice Hall, 2002.

[5] S. Beucher, "Watersheds of functions and picture segmentation," in Proc.IEEE Int.Conf. Acoustic, Speech, Signal processing pp.182-931, 1982.

[6] Gonzalez & Woods, Digital Image Processing 3rd edition, Prentice Hall India, 2008.

[7] K. Parvati, B. S. Prakasa Rao and M. Mariya Das, "Image Segmentation Using Gray-Scale Morphology and Marker-ControlledWatershed Transformation", Discrete Dynamics in Nature and Society,vol. 2008, pp. 1-8, 2008.

[8] Bieniek, A., & Moga, A., "An efficient watershed algorithm based on connected components", Pattern Recognition, 33, 907-916, 2000

[9] Jie Chen, Meng Lei, Yao Fan, Yi gao, "Research on an improved Watershed algorithm to Image segmentation", The 7th International Conference on Computer Science & Education (ICCSE 2012), 2012

[10] D Marr and E Hildreth, "Theory of edge detection", in proceedings of the Royal Society, vol. 207, pp. 187-217, London, 1980.

[11] Vincent, P.Soille,"Watersheds in Digital Space: "an Efficient Algorithms Based on Immersion Simulation," [J]-IEEE Transactions on Pattern Analysis and Machine Intelligence, 13, No.6, pp.583-598, 1991.

[12] Pinaki Pratim Acharjya ,Dibyendu Goshal, "A Gradient Based Morphological Watershed Segmentation Approach Suitable For Human Visual System" International Journal of Computer Science and Engineering(IJCSE) ISSN 2278-99960, vol.2, Issue 1, Feb 2013, 59-68.