ISSN: 2277-9655
Scientific Journal Impact Factor: 3.449
(ISRA), Impact Factor: 1.852

IJESRT
INTERNATIONAL JOURNAL OF ENGINEERING SCIENCES & RESEARCH TECHNOLOGY

Modified Watershed Transform using Convolution filtering for Image Segmentation

Rupinder Kaur[1] Er. Garima Malik[2]
Dept. of Electronic Communication and Engineering, GIMET, Amritsar, (Pb.), India
rksheen@hotmail.com

Abstract

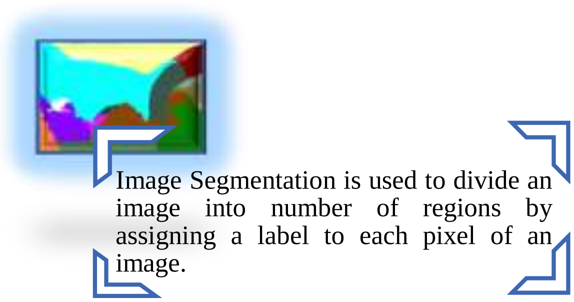
Image segmentation and evaluation are awfully not easy but significant tribulations in computer vision. In this article, we have present a Modified Watershed method for image segmentation. In this techniques, we used Convolution filtering, Dynamic thresholding and Masking, Morphology operations on input image. Two existing methods such as Region Growing and FCM are compared Modified Watershed methods by Metric Evaluation. This experimental results computed on MATLAB software with Image Processing toolbox.

Keywords: Fuzzy C-Means, Region Growing, Watershed transform, PSNR, MSE,RMSE, BER,SSIM.

Introduction

Image segmentation plays an important role in image engineering, it divide an image into number of constituent regions or categories by assigning label to each pixel of an image which correspond to different objects or parts of objects so that each region may give information regarding an object or area of interest and produces a binary image where pixel value one belongs to object, otherwise it is zero. This division of region is done to know which pixel belongs to which object(depends on color, spectral profile, motion etc).

Figure 1: *Image Segmentation*



Different techniques are available to facilitate the performance of image segmentation such as pixel based, edge based, cluster based, region based, model based, color based and hybrid[1]. Various techniques have been presented for segmenting color image and no one could at all times performs well on different types of images. For example, Edge based method may not achieve region boundaries, although the region-oriented algorithms could lead to over-segmentation otherwise under segmentation difficulties. For satisfying results, different optimization techniques for image segmentation, commonly researchers may have to use a user interaction process or extremely time consuming methods [2].

A watershed transform technique is commonly used in recent years for image segmentation. It is the most powerful method used for segmentation due to its advantages like simplicity, speed and complete division of an image, applications in variety of fields such as computer vision, biomedical, medical image segmentation. It is also based on morphology operations. This method is similar with region growing method; it begins with Growing process from every regional minimum value and each creates single region after transform. It combines together both similar and dissimilar properties efficiently. It works very well when it distinguishes background location and foreground object in an image[1][3]. The foremost disadvantage of watershed method is over-segmentation, very sensitive to noise and high computational complexity those make it unsuitable for real-time process [4]. And another drawback is that it create uncertain boundary on homogeneous region so this may lead watershed method is applied on gradient image[5]. To overcome over-segmentation, Adaptive threshold, adaptive masking, N-dimensional convolution, impose minima for morphological processing with watershed algorithm used called Modified Watershed Transform.

In this paper, we have presented different methods of segmentation such as FCM, RG, and comparing their results with Modified watershed transform(MWS) algorithm on 5 different types of images. Parameters used are: PSNR and MSE, RMSE, BER,SSIM.

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Related research

Watershed transform used with great interest in modern years as an efficient morphological image segmentation tool.
Vijay Jumb et al.[6] purposed a method of color image segmentation using HSV color space and K-Means clustering method along with Morphology processing.

Pinaki Pratim achariya et al.[7] advocated an approach for segmentation using median filter and watershed transform with distance transform over noise free image obtained after filtering.

Samina Tahir Rizvi et al.[8] described denoising and segmentation of many images using morphological filter and watershed transform. Median filters used to improve the results of watershed algorithm.

Inderpal et al.[9] presented the performance evaluation of different kinds of image segmentation methods.The objective of this paper was to design and implement different methods of image segmentation.

Md. Habibur Rahman et al.[10] presented image segmentation algorithm based on adaptive thresholding and masking with watershed algorithm. Whose objective is to overcome over-segmentation problem of the traditional watershed algorithm.

D. Nepoleon et al.[11] presented marker controlled Watershed image segmentation for verdict of objects by applying morphological operations on medical images.

Farheen K. Siddiqui et al.[12] purposed a method of segmentation is to boost the morphological watershed with enhanced edge detection and color histogram algorithm.

Anju Bala et al. [13] has described a novel method of image segmentation consist of image enhancement and noise removal techniques with Prewitt edge detection that successfully reduce the over-segmentation and attain more precise segmentation performance than the available method.

Ashwin Kumar et al.[14] studied a color image segmentation of automatic seed region growing from beginning of the region with grouping of watershed algorithm. for For extraction of the connected components of the image, Texture Gradient is used . last one Gradient image is the input to watershed algorithm.

M.C Jobin Christ et al.[15] purposed a methodology that uses Clustering and Watershed algorithm. The aim of this paper was to reduce number of false edges and over-segmentation.

Adapted watershed method

In this part, Adapted Watershed method is purposed for color images that will easily calculate each region of watershed segmentation. This is improved by taking into account an dynamic thresholding, adaptive masking, local minimum information and convolution fuction.
Following steps are used for this process.

Step 1: In this step input colored image is used and take out (R), green (G) and blue (B) color channels from input image showen in figure 1. Every channel is normalized from zero to one. Image normalization process is calculated by given equation:

$$N = \frac{I - mini(I)}{maxi(I) - mini(I)} \quad \text{.....1}$$

Where, the extracted three color channels represented by I. Image normalization is denoted by N.

Figure 2: Extract Original image into R, G and B channels

Step 2: for dynamic thresholding figure 2 , we need dynamic selection process based on grey threshold function is given by :

$$T_1 = G_t(N)$$
$$T_2 = G_t\big(N(N > T_1)\big)$$

Where $T_1 and\ T_2$ = Dynamic Threshold
G_t = Grey Threshold

Step 3: For N – Dimensional Convolution Filtering, N – Dimensional Grid Space is required. We have applied both image normalization and N – Dimensional Grid Space to N – Dimensional Convolution Filtering on three channels for smoothing image.

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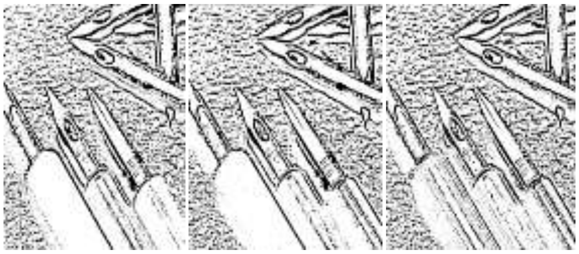

Figure 3: Convolution Filtering

Step 4: To overcome the noise problem easily, we use some mask to filter the holes or outlier. For that reason, the problem of noise does not exist. It is divided into two stages called cell masking and nucleus masking .This can be applied with formula is :

$$M_1 = \ N > T_1$$
$$M_2 = \ N > T_2$$

Where M_1 = Cell Mask
M_2 = Nucleus Mask

The adaptive masking operations are used image normalization (N) and Dynamic thresholding (T1and T2) on the R, G and B color channels as shown in Figure 3.

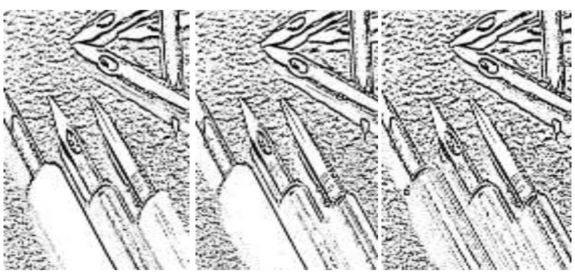

Figure 4: Adaptive Masking operation on RGB channels

Step 5: An image may have numerous regional maxima or minima with one global maxima or minima, So we created new minima in the masking over preferred position by dynamically choosing threshold values (T1 and T2) for morphological operations to eradicate all minima from an image excluding the minima we specified. Dilation and erosion operation are performed o all these three channels of original image as shown below. After that applying morphological operation on these three channels we get given images in figure 5.

Figure 5: Morphological operation on three color channels

Step 6. Watershed transform is applied based on the morphological operation image over R, G and B color channels for segmentation.

Step 7. Pixel labeling procedure initiated on each colored channel after applying watershed transform. To find out background image, we have used Wn = 0. Ln = bwlabel (Wn) function, returns a matrix Ln, includeing the labels for the linked items in the 2-D binary image over each color channel. The elements of Ln ≥ 0, Where, n is the number of channel. It will label foreground items in the binary image. The pixels labeled 0 are the background image. The pixels labeled as 1 create object 1, the pixels labeled 2 build up object 2 and so on.

Step 8: In this stage, we have transformed R, G and B label images into RGB image or color channels are summed to produce final segmented images as shown in figure 6.

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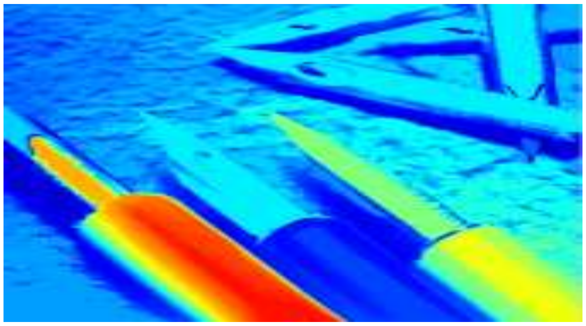


Figure 6: *Final segmented image*

Evaluated metrics

1. Peak Signal to Noise Ratio(PSNR)

$$\text{PSNR in db} = 10\log_{10}(255^2/MSE) \quad \text{....1}$$

2. Mean Squared Error(MSE)

$$\text{MSE} = \sum_t \sum_f \frac{\left(Y(i,j)-Y'(i,j)\right)^2}{M\times N} \quad \text{....2}$$

3. Root Mean Square Error(RMSE)

$$\text{RMSE} = \frac{1}{MSE} \quad \text{....3}$$

4. Bit Error Rate(BER)

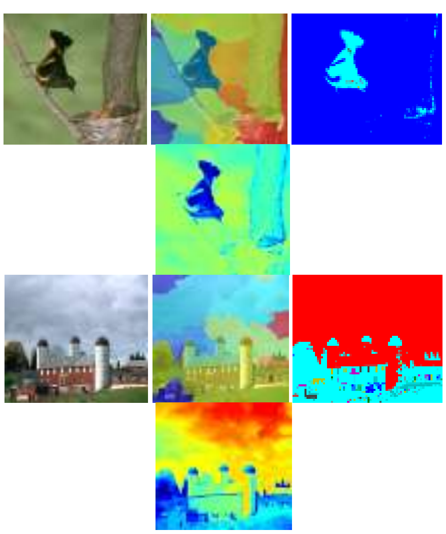
$$\text{BER} = \frac{\text{Number of errors}}{\text{Total number of tarnsmitted bits}} \quad \text{....4}$$

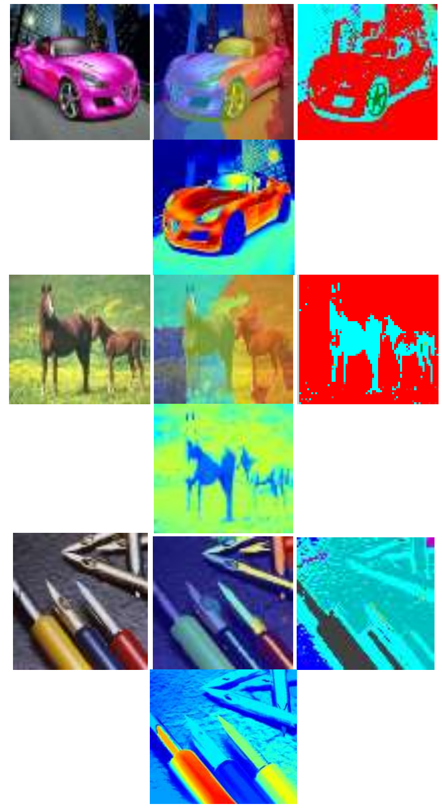
5. Structural Similarity index mean (SSIM)

$$\text{SSIM}(x,y) = \frac{(2\mu_X\ \mu_Y + C_1)}{(\mu_X^2 + \mu_Y^2 + C_1)} \frac{(2\sigma_{XY} + C_2)}{(\sigma_X^2 + \sigma_Y^2 + C_2)} \quad \text{....5}$$

Experimental results

All the images taken from Berkeley database [16] in figure 8 and adapted method is compared over two methods such as FCM and region growing. All these methods are implemented in MATLAB code.





Original RG FCM MWS

Figure 9: Comparison of FCM, RG and MWS methods

5 unlike types of images are namely "Bird", "Building", "Car", "Horses", "Pens". It is apparent from the figures that our Adapted modified watershed method performs well than two types of segmentation algorithms.

Metrics evaluation

In this section , we are quantitatively comparing the performance of Modified Watershed methods with FCM and RG with respect to PSNR,MSE, RMSE, BER,SSIM.

Table 1 : Performance of Three methods using PSNR, SSIM

Image	Metric (db)	RG	FCM	MWS
Bird	PSNR	32.2260	32.1723	32.1549
	SSIM	39.2536	39.7424	39.9016
Building	PSNR	27.6215	31.3466	31.3413
	SSIM	45.1163	48.0644	48.1228
Car	PSNR	28.7164	32.7164	32.7164
	SSIM	32.0111	35.0619	35.7619

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Horses	PSNR	21.4604	31.3608	31.4608
	SSIM	31.1071	47.9074	48.9074
Pens	PSNR	29.9347	32.8922	34.8783
	SSIM	22.5283	33.6715	33.9790

Table 2 : Performance of Three methods using MSE, RMSE, BER

Image	Metric (db)	RG	FCM	MWS
Bird	MSE	0.1310	0.0115	0.0192
	RMSE	6.9653	6.3042	6.3768
	BER	0.4539	0.0311	0.0311
Building	MSE	1.0157	0.0057	0.0064
	RMSE	7.9121	6.9328	6.9371
	BER	0.4215	0.0319	0.0320
Car	MSE	0.4384	0.0489	0.0049
	RMSE	6.9113	5.9213	5.8120
	BER	0.1306	0.0306	0.3304
Horses	MSE	0.1034	0.0034	0.0034
	RMSE	1.9111	6.9215	7.9215
	BER	0.2309	0.0319	0.1319
Pens	MSE	0.2783	0.0054	0.1054
	RMSE	8.1565	5.8027	6.8027
	BER	0.1334	0.0304	0.0300

Conclusion

At the end of this paper, it is evident from introduction and performance evaluation of all existing methods such as Region growing , FCM and Modified Watershed method, excluding Region growing, both methods are giving better results over PSNR, SSIM, MSE, RMSE, BER metrics.To conclude that, both methods appears to be good in case of speed and reduction of over segmentation. For the outlook, both FCM and Watershed method can be combined for better results and other parameters can be acquired.

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