논문 2007-44SP-3-6

영역기반 방법의 영상 분할에서 과분할 방지를 위한 Adaptive Trimmed Mean 필터에 관한 연구

(A Study of ATM filter for Resolving the Over Segmentation in Image Segmentation of Region-based method)

이 완 범*

(Wan-Bum Lee)

요 약

영상 분할은 주어진 영상에서 관심 영역을 추출하거나 압축을 위한 비디오 처리 분야에서 중요한 부분이며 특히 영역 기반 비디오 코딩에서는 필수적인 부분이다. 영역 기반의 수리형태학적 영상분할에서는 영상을 단순화한 후 추출된 경사 영상을 가지고 영역 경계를 결정하는 워터쉐이드 기법을 이용하는 방법이 주로 제안되고 있다. 이 방법은 병합될 대상 영역의 수가 많아질수록 병합하는 과정에 필요한 계산량이 지수적으로 증가하고, 영상 내의 잡음이 직접 국부적 최소 점들로 표현되어 영역들의 경계에 대한 기울기에 영향을 주어 영상의 과분할을 초래하게 된다. 따라서 본 논문에서는 이러한 영상의 과분할 문제를 해결할 수 있는 ATM 필터를 제안하였다. 모의실험 결과 제안된 ATM 필터가 전체적인 잡음제거의 향상과 함께 잡음 비율이 20% 이상일 경우의 영상의 선명도 훼손의 정도가 줄어들었음을 확인하였다.

Abstract

Video Segmentation is an essential part in region-based video coding and any other fields of the video processing. Among lots of methods proposed so far, the watershed method in which the region growing is performed for the gradient image can produce well-partitioned regions globally without any influence on local noise and extracts accurate boundaries. But, it generates a great number of small regions, which we call over segmentation problem. Therefore we proposes that adaptive trimmed mean filter for resolving the over segmentation of image. Simulation result, we confirm that proposed ATM filter improves the performance to remove noise and reduces damage for the clear degree of image in case of the noise ratio of 20% and over.

Keywords : Video processing, Image segmentation, Mathematical morphology

I. Introduction

Image segmentation algorithm consists of edge-based method based on the discontinuity, region-based method based on the balance of luminance and motion-based method based on the motion vector. The morphological approach among region based methods is generally applied[1][2].

* 정회원, 원광대학교 전기전자 및 정보공학부
(Department of Electrical Electronic and Information Engineering, Wonkwang University)
접수일자: 2006년10월1일, 수정완료일: 2007년4월17일

Region based approach is based on the similarity of pixels and classifies the pixels according to a criteria of similarity by comparing it with its neighborhood pixels. Mathematical morphology is used as a tool of signal processing with the object oriented characteristics of type, size and connectivity.

Image segmentation using mathematical morphology consists of 4 steps as follows[3][4].

Step 1 simplifies the image, and step 2 extracts gradient image from image and step 3 detects the edge of regions with a uniform characteristics by applying the watershed algorithm. Final step merges

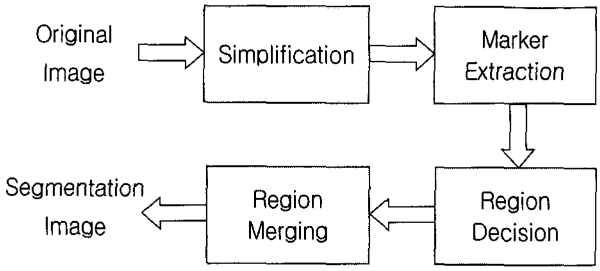


그림 1. 수리 형태론을 이용한 영상 분할의 흐름도
Fifg. 1. The flowchart of image segmentation using mathematical morphology.

a similar regions into a region in order to eliminate the segmented regions[4][5].

The prerequisite of edging of regions is the process of merging similar regions. But the more the number of regions merged, the more the time complexities of the merging process exponentially. In addition the downsizing of absolute size of each region is hard to extract the reliable measures for merging regions. The local minima of the noise in watershed using gradient image leads to over segmentation. The tilt of gradient to be segmented is strongly depended on the exactness of image segmentation, deciding the efficiency of segmentation. In this paper the ATM(Adaptive Trimmed Mean) filter is proposed which reduces the over segmentation by reducing the noise with the edge of regions clear before deciding the gradient tilt.

II. The simplification of input image

The simplification at the first stage of image segmentation is the stage which simplifys the input image by reducing the noise and the texture in the image with keeping the edges considered as the candidates of the edges of regions.

1. Opening-closing filter

Morphological filter consists of the combination of dilation and erosion which do not deteriorate the information of edges and simplify it. Dilation and erosion operations is defined as follows where x_i and y_i are input and output at N dimension respectively and b_n is flat morphological element with size n [5][6][7].

$$\text{dilation}: y_i = \delta_n(x_i) = Max\{x_{i-k}, k \in b_n\} \quad (1)$$

$$\text{erosion}: y_i = \epsilon_n(x_i) = \min\{x_{i+k}, k \in b_n\} \quad (2)$$

The original image is the reference image in dilation and erosion and opening and closing are the operations to dilation and erosion with $n \times n$ structuring element.

$$\text{opening}: \ \gamma^{(rec)}\{\epsilon_n(x_i), x_i\} \quad (3)$$

$$\text{closing}: \ \phi^{(rec)}\{\delta_n(x_i), x_i\} \quad (4)$$

The combination of the above operations leads to the filter of opening-closing.

$$\text{OC}: \ y_i = \phi^{(rec)}\gamma^{(rec)} \quad (5)$$

The scheme of opening-closing is closing operation which follows opening operation. This operation has the shortcuts of time complexities in operation due to the slow convergence of formula (3) and (4).

2. Median filter

The median filter $med(x_i)$ of data $x_i\,(i=1,\ldots\ldots,n)$ is defined as formula (6).

$$med(x_i) = \begin{cases} x_{(v+1)} & , n = 2v+1 \\ \dfrac{1}{2(x_{(v)} + x_{(v+1)})} & , n = 2v \end{cases} \quad (6)$$

Here x_i is i-th order statistics. One dimensional median filter is as formula (7) where $n = 2v+1$

$$y_i = med(x_{i-v}, \cdots, x_i, \cdots, x_{i_v}), i \in z \quad (7)$$

Where z is search window.

Formula (7) outputs the average value within 5×5 window with a fixed window.

The pixels of 3×3 window for the median filter are sorted ascendingly and the center of sorted pixels are selected as the value of median filter. The process is depicted in figure 2[5][6][7].

The gray level of each pixel is expressed as the center value within the neighbor pixels with the

	4	4	3	5	
	2	10	3	4	
	5	2	4	4	

(a) Original image

	4	4	3	5	
	2	4	3	4	
	5	2	4	4	

(b) Filtering image

그림 2. Median filtering 과정 예
Fig. 2. The process of median filtering.

original pixel value. Then this median filter has a drawback in performance over more than 0.2 in noise density. Therefore in this paper adaptive trimmed mean filter is proposed which can reduce the noise over more than 0.2 in noise density in order to overcome its drawback,

Ⅲ. Proposed adaptive trimmed mean filter

Median filter is the method for selecting the center value among the sequential values and the process of dividing the summation of the sequential values by the number of pixels. The proposed adaptive trimmed mean filter is based on the probability of filter with S_{xy}window of $m \times n$ rectangular, which is the adaptive version of α-trimmed mean filter.

$g(s,t)$ within S_{xy} window considers the uniform ratio of the big and small parts of gray levels as outlier to noise and $g(s,t)$ without outlier corresponds to the gray level and is described as formula (8).

$$\hat{f}(x,y) = \frac{1}{mn(1-2d)} \sum_{(s,t) \in S_{xy}} g(s,t) \tag{8}$$

Here d is the parameter used to reduce the big and small parts of gray levels in $S_{xy}$and it has the range of 0~0.5. The proposed filter is the method to minimize the error after the reduction of the big and small parts of the sequential errors within the window in the ratio of d. In case of d=0, it works as arithmetic mean filter in the form of the average of total values of distance and median filter in case of d=0.5.

This adaptive trimmed mean filter algorithm works as follows;

Stage 1 : A1 = $z_{med} - z_{min}$
A2 = $z_{med} - z_{max}$
If A1 > 0 AND A2 < 0, Go to Stage 2

Stage 2
Else increase the window size
If window size $\le S_{max}$ repeat stage 1
Else output z_{xy}

Stage 3 : B1 = $z_{xy} - z_{min}$
B2 = $z_{xy} - z_{max}$
If B1 > 0 AND B2 < 0, outputz_{xy}
Else output z_{med}

Here z_{min} is a minimum of gray level within window S_{xy} and z_{max} is a maximum of gray level within window S_{xy}, which mean the impulse noise. And z_{med} is a medium of gray level within window S_{xy}, and z_{xy} is a gray level of (x,y) coordinate, and S_{max} is a maximum of tolerance size.

This adaptive characteristics is depended on window size according the density of noise. Hence the clearness of image is maintained more than 0.2 in noise.

Ⅲ. Simulation

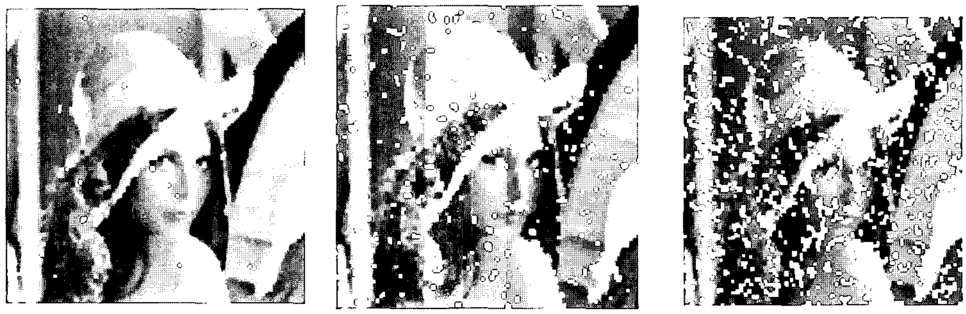
In this paper the reduction of noise casts adaptive characteristics on the structure of α-trimmed mean

그림 3. Lena의 원 영상
Fig. 3. Original Lena image.

(a) 10% (b) 20% (c) 30%

그림 4. salt-and-pepper noise가 10, 20, 30% 포함된 영상

Fig. 4. Image with 10%, 20%, 30% of salt-and-pepper noise respectively.



(a) 10% (b) 20% (c) 30%

그림 5. Opening-closing filter를 적용한 결과 영상

Fig. 5. The result image by Opening-closing filter.

(a) 10% (b) 20% (c) 30%

그림 6. Median filter를 적용한 결과 영상

Fig. 6. the result image by Median filter.

(a) 10% (b) 20% (c) 30%

그림 7. ATM filter를 적용한 결과영상

Fig. 7. The result image by ATM filter.

표 1. 각 알고리즘과 잡음비율별 MSE와 SNR
Table 1. MSE and SNR according to each algorithm.

알고리즘 \ 잡음비율		10%	20%	30%
Opening -closing	MSE	28.3512	31.1652	32.4238
	SNR	33.5589	33.1474	33.0016
Median	MSE	25.1284	25.3424	27.7579
	SNR	34.8284	34.7836	34.5253
Adaptive trimmed mean	MSE	19.4266	19.8867	20.2928
	SNR	35.2349	35.1110	35.0231

filter. And it is confirmed that the proposed adaptive trimmed mean filter is efficient more than the conventional opening-closing filter and median filter through the simulation of MSE and SNR using MATLAB.

Figure 3 is lena image and in Figure 4, (a) is image with salt and pepper noise and (b) and (c) are image with 20% and 30% noise respectively. Figure 5 is image free of noise using opening-closing filter and Figure 6 is image free of noise using median filter. And Figure 7 is image free of noise by ATM(Adaptive Trimmed Mean) filter.

Table 1 is the analysis of MSE and SNR of original and result images by opening-closing and median filter and adaptive trimmed mean filter in case of 10, 20, 30% salt and pepper noise respectively.

Ⅳ. Conclusion

Morphological image segmentation decides the edge of regions with gradient image extracted from a simplified image. Then the more the number of regions to be merged the more exponentially the time complexity to be met in the computation process.

In addition because the absolute size of each region shrinks, it is hard to induce the reliable measure to merge the regions. In particular as the noise in image is represented as local minima in the watershed algorithm which extracts the gradient image.

Therefore the adaptive trimmed mean filter is proposed in order to reduce this noise. As the noise density increases within image, the proposed filter is less 8.9246~12.131 in MSE than opening-closing filter and 5.7018~7.4651than median filter at Table 1 through the simulation.

It is guaranteed that the proposed established generally the efficiency of noise reduction and the maintenance of the clearness of image. Hence this approach is less vulnerable to oversegmentation in morphological gradient operations of image with noise.

참 고 문 헌

[1] Rafael C. Gonzalez, Richard E. Woods, "Digital Image Processing" 2nd ed., Prentice Hall, 2001
[2] Thomas. Sikora, "The MPEG-4 Video standard verification model" IEEE Transaction on Circuits and Systems for Video Technology, Vol. 7, No. 2, pp. 19-31, Feb. 1997.
[3] Gregory A. Bzxes. "Digital Image Processing" Edtech, 1994.
[4] P. Salembier, "Morphological multiscale segmentation for image coding", Signal Processing, Vol.38, pp. 359-386, 1990
[5] K. R. Kim and O. S. Choi, "A Study of Image Segmentation using Watershed Algorithm Applied by the gardual Marker", Proceedings of fall conference 2000, Korea Multimedia Institute, pp. 183-186, Nov. 2000.
[6] P. Salembier and M. Pardas, "Hierarchical morphological segmentation for image sequence coding", IEEE Tran. on Image Processing, Vol.13, N.5, pp.639-651, 1994.
[7] F. Dufaux and F. Moscheni, "Motion estimation techniques for digital TV a review and a new contribution," Proc. IEEE, Vol. 83, No. 6, pp. 858-876, June 1995.
[8] T. G´eraud, P.Y. Strub, and J. Darbon, "Color image segmentation based on automatic morphological clustering," in IEEE International Conference on Image Processing, 2001, vol. 3, pp. 70-73.
[9] I. Feldmann, S. Askar, N. Brandenburg, and O. Schreer P. Kauff. "Real-Time Segmentation for Advanced Disparity Estimation in Immersive

Videoconference Applications". In Proceeding of WSCG 2002, 10th Int. Conference on Computer Graphics, Visualization and Computer Vision, Plzen, Czech Republic, Feb. 2002.

저 자 소 개

이 완 범(정회원)
1995년 원광대학교 전자공학과 공학사 졸업.
1997년 원광대학교 전자공학과 공학석사 졸업.
2004년 원광대학교 전자공학과 공학박사 졸업.
2007년 현재 원광대학교 전기전자 및 정보공학부 강의교수
<주관심분야 : 영상처리, 디지털신호처리, VLSI 회로 설계>