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A COMPARATIVE STUDY ON THE METHOD OF EXTRACTING EDGE AND CONTOUR INFORMATION OF MULTIFUNCTIONAL DIGITAL SHIP IMAGE

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ABSTRACT

The result of the extraction of the edge and contour information of the multifunctional digital ship image directly affects the evaluation and recognition of the subsequent image quality. At present, the common method used to extract the edge contour information is based on the Canny operator, and there is a problem that the edge is not clear.In order to obtain more accurate edge information, a method of extracting edge and contour information of multimedia digital image based on multi-scale morphology is proposed. Firstly, the digital ship image is made double filter and the fuzzy threshold segmentation, and then the edge and contour information is extracted by multi-scale morphology. Experiments show that the proposed method can obtain more accurate edge information compared with the other methods.

Keywords: multifunctional digital image, edge and contour information, extraction

INTRODUCTION

Human vision is usually through the target object's edge and contour[1], to distinguish the target objects [2-3], whereas in the multifunctional digital ship image, the edge is an important feature that distinguishes different regions[4-5]. The edge and contour information of multifunctional digital ship image refers to the part of that the local brightness changes significantly[6], it exists between the target image and another target image[7], the target image and background image, the regional image and another regional image[8-9]. At present, the edge feature extraction technology of multifunctional digital ship image has been widely used in the field such as target tracking, fingerprint recognition, laser remote sensing image segmentation and many others. The edge and contour information extraction of multifunctional digital ship image, has become one of the hot research topics [10-12]. In reference [13], a method of extracting edge and contour information of multifunctional digital ship image based on self-enhancement is proposed. Firstly, the multifunctional digital image is subjected to make smoothing denoising by small-scale Gaussian filtering, and then the Canny edge detection operator is used to obtain the feature guidance information of the multifunctional digital image. In addition, each search of the multifunctional digital image is made sub-edge accumulation, and the edge and contour information of multifunctional digital image is extracted according to the degree of self-enhancement accumulation. The method has serious noise effects, and the extracted image edge and contour information is not clear. In reference [14], a method for edge and contour information extraction of multifunctional digital image based on Sobel operator gradient multiplication is suggested. In this method, the features of the target to be identified is to be extracted for the multifunctional digital image firstly. Then, the Sobel operator and the Roberts operator are used to extract the edge of the multifunctional digital image respectively. The two gradient amplitude images are calculated by gradient multiplication, to complete the edge and contour information extraction of the multifunctional digital image. The method does not make image denoising, and there are many small edge redundancy information. Aiming at the problems in the application of the above methods, this paper presents a method for extracting the edge and contour information of multifunctional digital ship image based on multi- scale morphology by comparing the edge and contour information extraction method of multifunctional digital ship image. Through the experimental comparison and verification, the proposed method can eliminate the noise interference in the image, extract the more accurate edge and contour information, and can keep the better edge detail. Experimental results show that the proposed method can eliminate the influence of noise and preserve the details of the edge contour information of the image, and has good practical value.

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A. COMPARISON OF SMOOTH DENOISING METHODS FOR MULTIFUNCTIONAL DIGITAL SHIP IMAGES

(a) Multifunctional digital ship image denoising based on wavelet adaptive threshold

According to the wavelet decomposition characteristics of multifunctional digital ship image, the optimal threshold for denoising of different layer coefficients of multifunctional digital ship image after wavelet decomposition is determined[15-17], and the effect of smooth denoising is achieved. The specific process is as follows:

Assuming that a $M \times N$ -sized multifunctional digital ship image $z(i, j)$ is expressed as:

$$z(i,j) = y(i,j) + n(i,j) \tag{1}$$

Where , $0 \le j \le N-1$, $0 \le i \le M-1$; $i, j \in Z$ stands for the pixel position of the multifunctional digital ship image; $y(i,j)$ represents the noise-free multifunctional digital ship image; $n(i,j)$ represents the Gaussian white noise of the multifunctional digital ship image $N(0,\sigma^2)$. The discrete wavelet transform can be performed on both sides of the equal sign on the above equation (1), it can be got

$$W_z = W_y + W_n \tag{2}$$

Where W_z represents the wavelet coefficients obtained after wavelet transform of the digital ship image with noise; W_y represents the wavelet coefficients obtained by wavelet transform of the original multifunctional digital ship image; W_n represents the wavelet coefficients obtained by wavelet transform of Gaussian white noise. Since the characteristics of the wavelet transform are a linear transformation, then:

$$W_y = W_z - W_n \tag{3}$$

The threshold selection is the key step of wavelet denoising and contraction of multifunctional digital ship image. The threshold selection method of multifunctional digital ship image is:

(A) The calculated expression for the fixed threshold of the multifunctional digital ship image is:

$$T = \alpha\sqrt{2\ln A} \tag{4}$$

Where A represents the length of the wavelet coefficient of the multifunctional digital ship image; α represents the standard deviation of the multifunctional digital ship image noise; T represents the estimation threshold of image. In practice, the variance of the image noise is unknown, and the standard deviation of the noise is estimated from the noisy signal of the multifunctional digital ship image. The expression is:

$$\alpha = Media(|Y_{ij}|)/0.6745 Y_{ij} \in subbanda \tag{5}$$

Where Y_{ij} represents the coefficient of standard deviation of the multifunctional digital ship image; HH_1 represents the sub-band coefficient of the multifunctional digital ship image.

(B) Threshold of Stein unbiased likelihood estimation of multifunctional digital ship image: a threshold a for the multifunctional digital ship image is set, to calculate its likelihood estimation; then, the threshold a of the multifunctional digital ship image is made non-likelihood minimization, thereby obtaining a selected threshold.

(C) When the image signal to noise ratio is small, if there is a large error in the unbiased likelihood estimation threshold, the fixed threshold method of (a) is used; otherwise, the unbiased likelihood estimation threshold is used.

(b) Assuming that the clear original multifunctional digital ship image is expressed as $u(x, y)$; the multifunctional digital ship image affected by noise is expressed as $u_0(x, y)$; the image noise is expressed as $n(x, y)$, since the noise has zero mean characteristic, the variance of the multifunctional digital ship image is expressed as σ_1 , then the energy function of the multifunctional digital ship image is expressed as:

$$\begin{aligned} TV_p\left[u(x,y)\right] &= \iint_\Omega \left|\nabla^p u(x,y)\right| dxdy \\ &+ \frac{\lambda}{2}\iint_\Omega (u(x,y) - u_0(x,y))^2 dxdy \end{aligned} \tag{6}$$

According to formula (6), a denoising TV_p model of multifunctional digital ship image is established, and the functional formula of multifunctional digital ship image is:

$$TV_p\left[u(x,y)\right] = \iint_\Omega F\left(x, y, u, \frac{\partial^p u}{\partial x^p}, \frac{\partial^p u}{\partial y^p}\right) dxdy \tag{7}$$

Where, ∂^p , x^p and y^p represent the noisy scale coefficient of the multifunctional digital ship image; λ represents the parameter value of the multifunctional digital ship image; F represents the noise difference value of the multifunctional digital ship image, and its formula is as follows:

$$F = \left|\nabla^p u(x,y)\right| + \frac{\lambda}{2}\left[u(x,y) - u_0(x,y)\right]^2 \quad \mathbf{(8)}$$

∇^p represents the substitution operator of the gradient operator ∇ of multifunctional digital ship image with the p-order differential. The necessary conditions for solving the extreme value of the functional of multifunctional digital ship image are:

$$\lambda(u-u_0) - \nabla^p\left(\frac{\nabla^p u}{\left|\nabla^p u\right|}\right) = 0 \quad \mathbf{(9)}$$

$$\nabla^p = \left(\frac{\partial^p u}{\partial x^p}, \frac{\partial^p u}{\partial y^p}\right) \quad \mathbf{(10)}$$

The Euler-Lagrangian equation of the denoising model TV_p of multifunctional digital ship image is:

$$\lambda = \frac{1}{|\Omega|\sigma_1}\int\int_{\Omega}\left[\nabla^p\left(\frac{\nabla^p u}{\left|\nabla^p u\right|}\right)\right](u-u_0)dxdy \quad \mathbf{(11)}$$

(c) The denoising method of multifunctional digital ship image based on double filtering

The filtering results of the four different directions of templates are carried out calculation, so as to obtain the filter value of the noise point in multifunctional digital ship image]. The details of the process are as follows:

For the noise point at (i_1, j_1) in the multifunctional digital ship image, the neighborhood size is expressed as $(2N_1+1)\times(2N_1+1)$, where N_1 is a positive integer. The process of filtering the multifunctional digital ship image by double discrete wavelet method is as follows:

$$\begin{cases} a_1(i_1,j_1) = Med\left[B(i_1+k,j_1), -N_1 \le k \le N_1\right] \\ a_2(i_1,j_1) = Med\left[B(i_1 j_1+k), -N_1 \le k \le N_1\right] \\ a_3(i_1,j_1) = Med\left[B(i_1+k,j_1+k), -N_1 \le k \le N_1\right] \\ a_4(i_1,j_1) = Med\left[B(i_1-k,j_1-k), -N_1 \le k \le N_1\right] \end{cases} \quad \mathbf{(12)}$$

Where $a_x(i_1,j_1)$ represents the filtered values of the four different directions of the multifunctional digital ship image; $Med[\bullet]$ represents the median filter of the multifunctional digital ship image; and $B(i_1,j_1)$ represents the gray scale matrix within a certain region of the multimedia digital ship image. The following calculations are made for the set $\{a_x(i_1,j_1)\}$:

$$\begin{cases} Z_{\max}(i_1,j_1) = \max\{a_x(i_1,j_1)\} \\ Z_{\min}(i_1,j_1) = \min\{a_x(i_1,j_1)\} \end{cases} \quad \mathbf{(13)}$$

Where $Z_{\max}(i_1,j_1)$ represents the maximum filter coefficient of the multimedia digital ship image; $Z_{\min}(i_1,j_1)$ represents the minimum filter coefficient of the multimedia digital ship image. For the noise point at (i_1,j_1) in the multimedia digital ship image, the filter value is calculated as follows:

$$f''(i_1,j_1) = Med\left[Z_{\max}(i_1,j_1), Z_{\min}(i_1,j_1), f'(i_1,j_1)\right] \quad \mathbf{(14)}$$

Where $f'(i_1,j_1)$ represents the gray value of any one of the pixels in multifunctional digital ship images.

The final filtering result of multimedia digital ship image is:

$$f'''(i_1,j_1) = \frac{P_1 a_{\max}(i_1,j_1) + P_2 a_{\min}(i_1,j_1) + P_3 a_{med1}(i_1,j_1) + P_4 a_{med2}(i_1,j_1)}{P_1+P_2+P_3+P_4} \quad \mathbf{(15)}$$

B. COMPARISON OF MULTIMEDIA DIGITAL SHIP IMAGE SEGMENTATION METHOD

(a) Multimedia digital ship image segmentation method based on kernel self-organizing map and graph theory

According to the theory of information, the kernel self-organizing map can be derived for multimedia digital ship image segmentation, and the specific process is as follows:

The statistical properties of the neuron output y' of multimedia digital ship image are expressed by the random variable Y_d and the probability density Y_d . The calculated expression of the deferential entropy of Y_d is:

$$H(Y_d) = -\int_{-\infty}^{\infty} P_{Y_d(y')}\log P_{Y_d(y')} e y_d \quad \mathbf{(16)}$$

For any random variables $\hat{Y}$ and $\hat{Y}$ in a multimedia digital ship image, the relational expression between the combination entropy $H(\hat{Y},\widehat{Y})$ and the mutual information $I(\hat{Y},\widehat{Y})$ is:

$$H(\hat{Y},\widehat{Y}) = H(Y) + H(\widehat{Y}) - I(Y,\widehat{Y}) \quad \mathbf{(17)}$$

(b) Multimedia digital ship image segmentation method based on fractal network evolution

The spectral heterogeneity calculation formula of multimedia digital ship image segmentation method based on fractal network evolution is:

$$h_{color} = \sum_{c'}(n_{merge}\times\sigma_{c'}^{merge} - (n_{obj1}\times\sigma_{c'}^{obj1} + n_{obj2}\times\sigma_{c'}^{obj2})) \quad \mathbf{(18)}$$

In the formula, n_{obj1} and n_{obj2} represent the number of pixels of two pixels before the multimedia digital ship images are merged; $\sigma_{c'}^{obj1}$ and $\sigma_{c'}^{obj2}$ represent the variance of the two pixels of the multimedia digital ship image; n_{merge} represents the variance of the pixel after the multimedia digital ship images are merged.

The shape heterogeneity of multimedia digital ship image segmentation method based on fractal network evolution is calculated as:

$$h_{shape} = w_{cmpct}\times h_{cmpct} - (1-w_{cmpct})\times h_{smooth} \quad \mathbf{(19)}$$

Among them, w_{cmpct} represents the compactness weight of multimedia digital ship image, the value interval is $[0,1]$; h_{cmpct} represents the compactness heterogeneity of the multimedia digital ship image; $(1-w_{cmpct})$ represents the shape heterogeneity weight of the media digital ship image; h_{smooth} represents the smoothing heterogeneity of the multimedia digital ship image.

The total heterogeneity calculation formula of the multimedia digital ship image segmentation method based on the analysis of network evolution is:

$$heterogeneity = \tilde{w} \times h_{color} + (1-\tilde{w}) \times h_{shape} \tag{20}$$

(c) Multimedia digital ship image segmentation method based on improved fuzzy threshold

Assuming that the size of the multimedia digital ship image G is expressed as $M' \times N'$, there are L levels of gray scale, expressed as $\{0,1,\cdots,L-1\}$; the membership function of the multimedia digital ship image in the L - level gray scale is expressed as $v(\hat{x})$; $h(i'')$ represents the number of pixels with the gray value of i'' in the multimedia digital ship image . The fuzzy rate of the multimedia digital ship image is expressed as:

$$v(\hat{x}) = \frac{2}{M' \times N'} \sum_{i''=0}^{L-1} h(i'') \min\left[\mu(i''), 1-\mu(i'')\right] \tag{21}$$

If the minimum gray scale value in the multimedia digital ship image indicates the gray scale range from the minimum value of the abscissa to the threshold T' in the gray scale histogram of multimedia digital ship image. The multimedia digital ship image is weighted and averaged, and the weight coefficient of the image is $g(\tilde{x})$. the weighted average value $\overline{a}$ of the multimedia digital ship image is calculated as:

$$\overline{a} = \sum_{\tilde{x}=a'}^{T'} \tilde{x} g(\tilde{x}) \tag{22}$$

Wherein, the weight coefficient of the multimedia digital ship image is $g(\tilde{x})$, indicating the proportion of the number of pixels which gray value is $\tilde{x}$ (i.e., the information represented by the ordinate in the gray scale histogram of the multimedia digital ship image) to the number of total pixels in the interval $\left[a', T\right]$. It can be seen, $\overline{a}$ will be close toward the corresponding gray value of the left peak, and fall in the adjacent location of its corresponding gray value. Similarly, the weighted average value b' can be calculated in the interval range from the threshold T' to the maximum gray scale value b' in the multimedia digital ship image, and the expression is:

$$\overline{b} = \sum_{\tilde{x}=T'}^{b'} \tilde{x} g(\tilde{x}) \tag{23}$$

Similarly, $\overline{b}$ will fall at the adjacent position of the gray value corresponding to the right peak. If $\left[\overline{a}, \overline{b}\right]$ is directly used as the search interval of the multimedia digital ship image, there is no guarantee that the interval length will be smaller than the peak separation after multiplying the coefficient $\beta(0.3 \sim 0.8)$ of multimedia digital ship image, and further improvement is required. Let $\overline{a}' = (a'+T')/2$, $\overline{b}' = (b'+T')/2$, then the calculation formula of window width $\hat{c}$ of multimedia digital ship image is:

$$\hat{c} = \beta\left[(\overline{b} - \overline{a} - \left|\overline{a} - \overline{a}'\right| - \left|\overline{b} - \overline{b}'\right|\right] \tag{24}$$

C. COMPARISON OF EDGE AND CONTOUR INFORMATION EXTRACTION METHODS FOR MULTIMEDIA DIGITAL SHIP IMAGE

For multimedia digital ship images, the continuous function variables of the digital ship image are usually approximated by the gray values of two adjacent points:

$$\nabla_{u'} = u'(m+1,n) - u'(m,n) \tag{25}$$

$$\nabla_{u'} = u'(m,1+n) - u'(m,n) \tag{26}$$

(b) Method of edge and contour information extraction for multimedia digital ship image based on mathematical morphology

Assuming that m structure elements of multimedia digital ship image are selected for mathematical morphology calculation, the multivariate element B_m of multimedia digital ship image is expressed as:

$$B_m = l_1 \oplus l_2 \oplus l_3 \oplus \cdots l_m \tag{27}$$

Supposing that $\phi(x'', y'')$ represents the input gray scale function of the multimedia digital ship image; $\varphi(x'', y'')$ represents the structural element function of multimedia digital ship image. Taking the structural element of the multimedia digital ship image with n' elements, and is defined in the structural element set R^2 or Z^2 of multimedia digital ship image, D_ϕ and D_φ respectively represent the definition field of gray function $\phi(x'', y'')$ and $\varphi(x'', y'')$ of multimedia digital ship image.

The weighted average of the structural element functions of the multimedia digital ship image with n' elements is calculated as:

$$\phi_{avr}(x'', y'') = \frac{1}{n'} \sum_{i=1}^{n'} (\lambda' \phi'(x'', y'')) \tag{28}$$

According to the importance difference of the structural elements in the multimedia digital ship image, the weight value is set, where $\lambda' \in [0,1]$.

If the corrosive operation is used, the edge detection operator of multimedia digital ship image is calculated as:

$$E'(x'', y'') = (\phi(x'', y'') \bullet B'(x'', y'')) \circ \phi_{avr}(x'', y'') - (\phi(x'', y'') \bullet B'(x'', y''))\Theta\phi_{avr}(x'', y'')$$

)

If the expansion-corrosion operation is used, the edge detection operator of multimedia digital ship image is calculated as:

$$E'(x'', y'') = (\phi(x'', y'') \circ B'(x'', y'')) \oplus \phi_{avr}(x'', \boldsymbol{y}'') - \\ - (\phi(x'', y'') \bullet \boldsymbol{B}'(x'', y''))\Theta\,\phi_{avr}(x'', y'') \tag{29}$$

Based on the above calculation, the n' edge detection operators of multimedia digital ship image can be obtained, and the appropriate weight is added to it, so as to obtain the multi-element edge detection operator of multimedia digital ship image. The formula is as follows:

$$E_{avr}(x'', y'') = \sum_{i=1}^{n'} a' E'(x'', y'') \tag{30}$$

Let the gray scale range of the multimedia digital ship image is $[1, L']$, the occurrence probability of image pixel in each gray scale is expressed as $P_0', P_1', P_2', \cdots, P_{l'}'$; the image processed by the edge detection operator $E'(x'', y'')$ of multimedia digital ship image is denoted as I', and the entropy of I' of multimedia digital ship image can be calculated as:

$$\begin{cases} eI' = -\sum_{\breve{k}}^{l} \log_2 \\ \breve{k} = 1, 2, \cdots, l \end{cases} \tag{31}$$

The weight value a'' of the extracted digital ship image entropy is:

$$a'' = eI' \Big/ \left[\sum_{\breve{k}}^{n'} eI' \right] \tag{32}$$

(c) Edge and contour information extraction of multimedia digital ship image based on multi-scale morphology

The edge and contour features of the image are extracted by using the structural elements with different sizes of multimedia digital ship images. In order to obtain more accurate edge detection information, it is necessary to adjust the size of the structural element scale reasonably. After comparative analysis, the multi-scale structural elements are used, and the expression is defined as:

$$\theta_\gamma = \theta \oplus \theta \oplus \theta \oplus \theta \cdots \oplus \theta \tag{33}$$

Where, γ stands for the scale parameter of the multimedia digital ship image, it is a positive integer; θ represents the finite structural element of the multimedia digital ship image, and θ is a cross-shaped 3×3 structural element. Equation (33) shows that the large-scale structural elements of a multimedia digital ship image are obtained by performing multiple expansion operations on the small-scale structural elements of the image. The expression of the multi-scale morphological edge detection operator of multimedia digital ship image is:

$$E_M(x'', y'') = \sum_{i=1}^{n'} a' E'(x'', y'') \tag{34}$$

Where, $E_M(x'', y'')$ is the new synthesized multimedia digital ship image.

SIMULATION RESULTS AND ANALYSIS

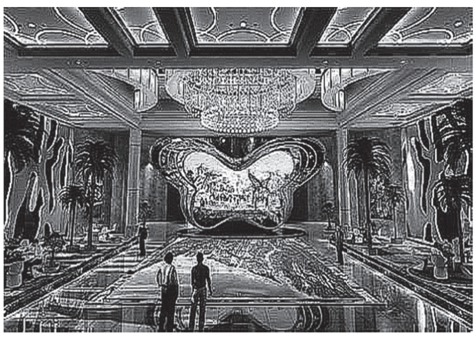
The experimental platform is MATLAB 7.0, and the computer installation with Microsoft Windows 7 Professional (SP2) operating system, Intel (R) Core (TM) CPU 2.6Hz, 4GB memory, and 720GB hard disk. Two 320 * 240 multifunctional digital ship images for experiment from google are randomly selected. The test images are shown in Figure 1(a1) and Figure 1(a2).The second picture is cabin picture.

In order to verify the effectiveness of the proposed method compared with other methods, 8Gaussian filter in reference [13] and double filter proposed in this paper are compared, and the results of the experimental analysis are shown in Figure 1.

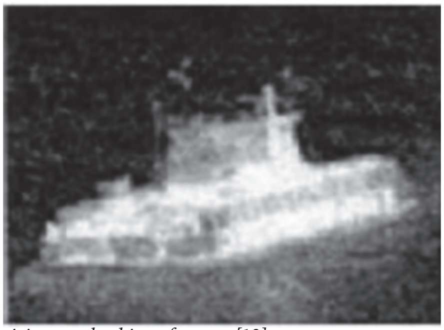
(a1) Original test Multimedia digital ship image

(a2) Original test Multimedia digital ship image

(b1) Denoising method based on Wavelet transform in section A

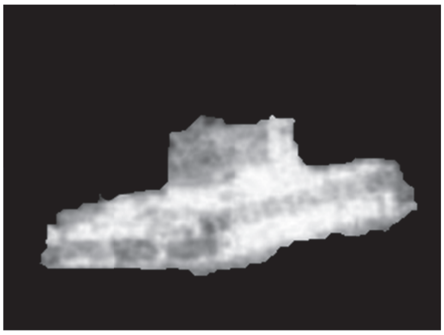


(b2) Denoising method based on Wavelet transform in section A

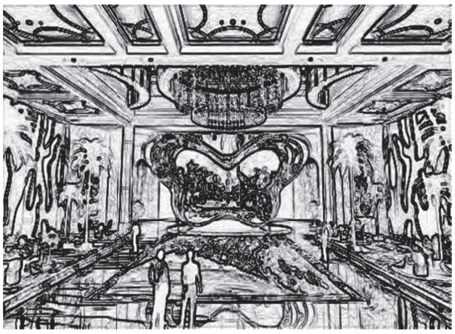


(c1) Denoising method in reference [13]

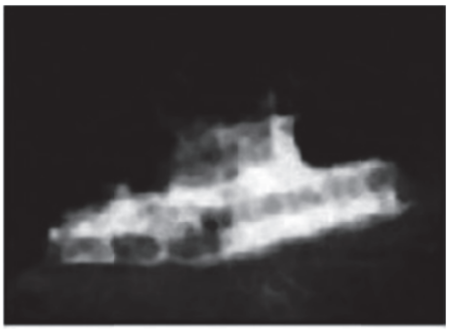
(c2) Denoising method in reference [13]



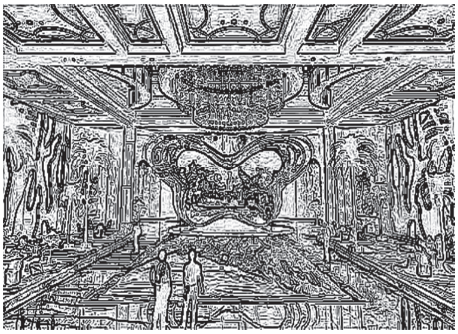
(d1) The results of edge extraction by the method in reference [13]



(d2) The results of edge extraction by the methodin reference [13]



(e1) The results of edge extraction by the proposed method



(e2) The results of edge extraction by the proposed method

Figure 1 Multimedia digital ship image

The comprehensive comparative analysis of Figure 1 can be seen, the denoising effect of wavelet transform method used in section A and Gaussian filter method used in reference [13] for multimedia digital ship image denoising is not ideal, seriously affect the subsequent image processing. It can be seen from the edge extraction effect of Fig. 1(e1) and Fig. 1(e2) that it still contains a certain noise in the edge extraction by the method of section C and the method of reference [13], resulting in the incomplete extraction of edge and contour information, which cannot get more accurate edge information[18-22]. Compared with the other two methods, the proposed method has obvious advantages, and the noise in the original multimedia digital ship image is removed well, retaining better detail information for the subsequent image segmentation and edge and contour information extraction.

The simulation results show that the proposed method can obtain the ideal image edge and contour information, and realize the bidirectional balance between the denoising and the accurate extraction of edge and contour information of the target image. Compared with the traditional edge and contour information extraction method, the extraction effect is greatly improved[23].

CONCLUSION

When the edge contour information of multimedia digital ship image is extracted by the current method, the image background cannot be better segmented with the image object because it contains a lot of noise, which can affect the quality of the subsequent image processing. This paper presents a method for edge contour information extraction of multimedia digital ship image based on multi-scale morphology. Experimental results show that the proposed method can eliminate the influence of noise and preserve the details of the edge contour information of the image, and has good practical value.

REFERENCE

1. Tandon R, Simeone O. Harnessing cloud and edge synergies: toward an information theory of fog radio access networks . IEEE Communications Magazine, 2016, 54(8):44-50.

2. Kuo P C, Lu K H, Hsu Y N, et al. Fast three-dimensional video coding encoding algorithms based on edge information of depth map. Iet Image Processing, 2015, 9(7):587-595.

3. Cheng B N, Kuperman G, Deutsch P, et al. Group-centric networking: addressing information sharing requirements at the tactical edge. IEEE Communications Magazine, 2016, 54(10):145-151.

4. Wen S, Haghighi M S, Chen C, et al. A Sword with Two Edges: Propagation Studies on Both Positive and Negative Information in Online Social Networks. IEEE Transactions on Computers, 2015, 64(3):640-653.

5. Liu X F, Yao X R, Lan R M, et al. Edge detection based on gradient ghost imaging. Optics Express, 2015, 23(26):33802.

6. Tseng C S, Wang J H. Perceptual edge detection via entropy-driven gradient evaluation. Iet Computer Vision, 2016, 10(2):163-171.

7. Hidalgogato M C, Barbosa V C F. Edge detection of potential-field sources using scale-space monogenic signal: Fundamental principles. Geophysics, 2015, 80(5):J27–J36.

8. Hidalgogato M C, Barbosa V C F. Edge detection of potential-field sources using scale-space monogenic signal: Fundamental principles. Geophysics, 2015, 80(5):J27–J36.

9. Liu X, Fang S. A convenient and robust edge detection method based on ant colony optimization. Optics Communications, 2015, 353(8):147-157.

10. Gardiner B, Coleman S A, Scotney B W. Multiscale Edge Detection Using a Finite Element Framework for Hexagonal Pixel-Based Images. IEEE Transactions on Image Processing, 2016, 25(4):1-1.

11. Zheng Y, Zhou Y, Zhou H, et al. Ultrasound image edge detection based on a novel multiplicative gradient and Canny operator.. Ultrasonic Imaging, 2015, 37(3):238-50.

12. Sharma B, Mahajan P. Latest trend of variation of EDGE detection and object detection with pixel level variation and their comparison algorithms. Genetic Epidemiology, 2015, 35(7):606-19.

13. Tschirhart P, Morris B. Improved edge detection mapping through stacking and integration: a case study in the Bathurst Mining Camp. Geophysical Prospecting, 2015, 63(2):283-295.

14. Qu Z, Fang X, Su H, et al. Measurements for displacement and deformation at high temperature by using edge detection of digital image.. Applied Optics, 2015, 54(29):8731.

15. 11.Gao, W. and W. Wang, The fifth geometric-arithmetic index of bridge graph and carbon nanocones. Journal of Difference Equations and Applications, 2017. 23(1-2SI): p. 100-109.

16. 12.Gao, W., et al., Distance learning techniques for ontology similarity measuring and ontology mapping. Cluster Computing-The Journal of Networks Software Tools and Applications, 2017. 20(2SI): p. 959-968.

17. Any support wen-quan zeng, ai-min yu. An effective medical noisy image edge detection method . Journal of electronic design engineering, 2016, 24 (10) : 180-183.

18. Rahman N A, HalimH, Gotoh H, Harada E. Validation of Microscopic Dynamics of Grouping Pedestrians Behavior: From Observation to Modeling and Simulation. Engineering Heritage Journal, 2017, 1(2):15–18.

19. Gao W,Rajesh Kanna M R, Suresh E, Farahani M R. Calculating of degree-based topological indices of nanostructures. Geology, Ecology, and Landscapes, 2017, 1(3): 173-183.

20. Farajollahi G, Delavar M R. Assessing accident hotspots by using volunteered geographic information. Journal CleanWAS, 2017, 1(2): 14-17.

21. Roslee R,Mickey A C, Simon N, Norhisham M N. Landslide Susceptibil ity Analysis (Lsa) Using Weighted Overlay Method (Wom) Along the Genting Sempah To Bentong Highway, Pahang. Malaysian Journal Geosciences, 2017, 1(2): 13-19.

22. Ismail M N, Rahman A, Tahir S H. Wave-dominated shoreline deposits in the Late Miocene Sedimentary Sequence in the Miri Formation North Sarawak, Malaysia. Geological Behavior, 2017, 1(2):14–19.

23. TengY, Zhou Q. Environmental effect of Sudan I-IV: adsorption behaviors and potential risk on soil. Acta Scientifica Malaysia, 2017, 1(1): 16-17.

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