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RESEARCH ON THE TARGET AND INTERFERENCE ADHESION PROBLEM IN THE INFRARED IMAGE SEGMENTATION

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Abstract

The infrared images are more widely used in the military field and people's daily life. There is adhesion between the targets and interferes because of the imaging effect is not ideal. In our paper, new infrared image segmentation based on the classic snake active contour model and mathematical morphology is proposed to resolve the interference adhesions problem. Firstly, image enhancement and noise smoothing method are used to enhance the infrared image. Secondly, snake active contour model is used to separate targets. Lastly, we use mathematical morphology method to separate the touched objects. The experiment show that satisfied object is obtained.

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1. Introduction

Because of the system and mechanism are different from the visible image, there are usually disadvantages in the infrared imaging, such as large interfering noise, image blurring, and low contrast. It is quite necessary to enhance infrared image target and reduce the image noise by using image enhanced and smooth method. After the infrared image enhancement, we need to choose the appropriate method to take apart the target and the background, because that outside interference always leads to target adhesion.

In the field of image segmentation, the Otsu algorithm proposed in [1] is widely used. However, Otsu algorithm only considers single pixel gray, which makes it sensitive to image noise. On this basis, a two-dimensional Otsu is put forward in [2], and the improved algorithm considers not only the single pixel gray level information, but the gray information of neighbourhood pixels, so it can suppress the image noise effectively. Although two-dimensional Otsu algorithm improves the anti-noise performance, it also greatly increases the calculation complexity, which limits the application area of the algorithm. Li puts forward an infrared image segmentation based on the combination of morphological and two-dimensional Otsu in [3], which can retain the image basic shapes and details and it can get more ideal segmentation results. Because of the different application background, the scholars put forward many different segmentation methods. According to the characteristics of the infrared image in this article, we use the snake active contour model to separate targets which can overcome the disadvantages such as unclosed edge image boundary, incomplete and incorrect segmentation etc. At the same time, the method is simpler than the other traditional image segmentation method.

To overcome target adhesion problems, in [4], the authors put forward a segmentation method of target adhesion based on mathematical morphology, which can realize the accurate segmentation of various X-ray images effectively. In [5], Cui and Jiang propose adhering segmentation based on local distribution characteristics of cell image. This method is simple, and has strong robustness and good segmentation effect. In [6], the authors put forward a touched object segmentation based on partial projection. And this method can also separate the target well under stronger adhesion. These methods can segment the target effectively, however, these method are complex and time costing. Aiming at simplifying adhesion infrared target, we use the mathematical morphological corrosion expansion segmentation, which is simple and effective.

2. The Infrared Image Preprocessing

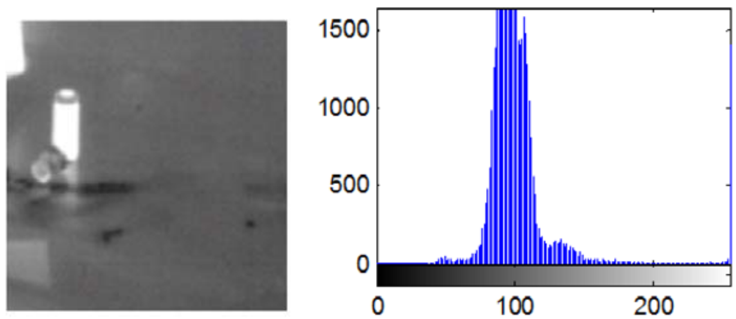
2.1. Histogram equalization

Infrared image histogram has the characteristics of narrow gray dynamic range, low contrast, and inconspicuous image detail feature. Using histogram equalization method can improve the image contrast. Transform the non-uniformity histogram of the original image into a uniform distribution histogram, which can increase the gray level of pixel dynamic range and improved the image contrast. It uses the method that makes the cumulative distribution function to be a conversion curve of image grey value. Use r_k to represent the k level of grey value, s_k to represent enhanced k level image pixel gray value [1, 2]. To normalize processing of r and s, the histogram equalization process can be expressed as:

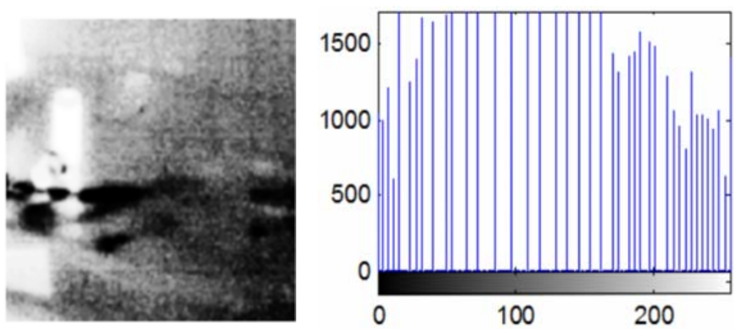
$$s_k = T(r_k) = \sum_{j=0}^{k} p_r(r_j) = \sum_{j=0}^{k} \frac{n_j}{n}, \qquad 0 \le r_k, s_k \le 1, k = 0, 1, 2, \ldots, L-1, \tag{1}$$

where T represents the enhancement function, p_r represents the original image gray histogram. After the transformation function, we can approximately transform gray level distribution of r into uniform distribution of s.

Figure 1 is an infrared image contrast before and after histogram equalization.



(a) The original histogram of the infrared image



(b) The enhanced histogram of the infrared image

Figure 1. Histogram equalization image enhancement.

By comparing before and after the processing of infrared image histogram, we can see that before processing, histogram concentrate in certain gray scale and the dynamic range is very narrow; after processing, histogram almost distribute in the whole of the gray level range. Meanwhile, the infrared target close to the background is highlighting and the entire infrared target is enhanced commendably.

The original unnoticeable infrared targets are effectively highlighted through histogram equalization. When we use snake image segmentation, it can lock the target edge more accurately and make the segmentation more accurately.

2.2. Image smooth

Infrared image has low signal noise ratio (SNR). It is necessary for us to remove partly noise with image smoothing. In order to suppress noise effectively and keep the image edge, we select the median filter to smooth image. Median filter is a nonlinear smoothing filtering, which can overcome detail fuzzy problems brought by the linear smoothing method under certain conditions [7-11]. We can know that the infrared image we get has simple background, which is suitable for using median filter. We can use square template sized 5^*5 to filtering the histogram equalized infrared image as shown in Figure 2.

(a) Enhancement image (b) Median filtering image (c) The noise image

Figure 2. Image smooth by median filtering image.

To compare the de-noised image in Figure 2(b) to the original enhancement image in Figure 2(b), we can get that median filter can remove the noise effectively and the image edge fuzzy will not appear. Figure 2(c) is the noise image by Figure 2(b) minus Figure 2(a), which visually shows the effect of median filtering. What’s more, median filter can obtain good effect of noise suppression in infrared image. Therefore, it won’t make the snake mistake large noise for target in the snake image segmentation.

3. The Infrared Image Segmentation

3.1. The snake basic behaviour

Using $v(s) = (x(s),\ y(s))$ to represent the position of the snake, we can write energy function as follows:

$$E^*_{snake} = \int_0^1 E_{snake}(v(s))ds = \int_0^1 E_{int}(v(s)) + E_{image}(v(s)) + E_{con}(v(s))ds, \quad (2)$$

where E_{int} represents internal force due to the snake bending, E_{image} represents the produced image force, and E_{con} represents the produced external force.

Internal curve constraining force can be expressed as the following formula:

$$E_{int} = (\alpha(s)|v_s(s)|^2 + \beta(s)|v_{ss}|^2)/2, \quad (3)$$

where curve energy is controlled by the first order $\alpha(s)$ and second order $\beta(s) \cdot \alpha(s)$ represents the tensile degree of image and $\beta(s)$ represents the flexible degree of image. Changing the proportion of $\alpha(s)$ and $\beta(s)$ will change the elongation and curvature, which determine the convergence of the contour. E_{int} shows the constraint to continuity and flatness of snake active curve.

3.2. The image force

The following three kinds of different energy function attract the snake to three different characteristics that are lines, edges, and terminals. The total energy of the image can be represented as a weighted combination of the following three kinds of energy function:

$$E_{image} = w_{line}E_{line} + w_{edge}E_{edge} + w_{term}E_{term}. \quad (4)$$

We can create all kinds of behaviours of snake by adjusting the weights.

3.3. The snake image segmentation

Since part of the infrared target grey values is close to the background, if we perform snake segmentation directly, the targeting is not accurate. The targeting is more outstanding and noise is less in enhanced infrared image. It is conducive for snake to target accurately and makes the segmentation more exactly. Therefore, we segment the enhanced infrared image. Figure 3 is the result of the infrared enhanced image segmentation using snake active contour model.

(a) The smooth image (b) The contour of image (c) Segmentation image

Figure 3. The snake infrared image segmentation process.

Figure 3(b) is the snake displaying result after energy minimization. It pinpoints the edge features. Figure 3(c) is the segmentation result of snake image segmentation. It implements infrared image segmentation. The target boundary is continuous, edge is closed and segmentation result is accurate.

4. Target and Interference Segmentation

Image after segmentation will have target adhesion, which is not conducive to target information extracted or characteristics. So we need further process to depart target and interference. Therefore, we choose mathematical morphology method to solve it. Mathematical morphology method not only can obtain better segmentation results but its process is simple. The basic idea to solve adhesion problem is processing images using structure elements. Thus, we choose a high feasibility segmentation method of corrosion and expansion based on mathematical morphology. For segmentation image, firstly, we use the method of mathematical morphology for corrosion. Expansion and corrosion are two contrary processes. Therefore, expanding the nuclear after corrosion can restore the original image. Hypothesis: A is the binary image corresponding to infrared image; B is the selected structural elements. For A and B in Figure 3, B of A corrosion or expansion operation process is as follows:

(1) Scan each pixel in images A with structural elements B.

(2) Do “and” arithmetic operations between structural elements B and the binary image it covers.

(3) Expansion: If they are both 1, the resulting image is 1 pixel. Otherwise it is 0 pixels.

Corrosion: If they are both 0, the resulting image is 0 pixels. Otherwise it is 1 pixel.

When B is symmetry about the origin, after A being corroded by B, A can maintain the basic shape. If B is selected as the small circle of radius r, every time corrosion will cause the peripheral of original image reduces r. Repeat the corrosion and there will be disconnected area.

Although corrosion can separate the adhesive target and expansion can connect the disconnect target, there is still a problem that the target area will be less than the original area after corrosion, and will be greater after expansion. Therefore, when deal with adhesive target, we use opening operation and closed operation method. Firstly, through opening operation, in order to disconnect the adhesive target, do expansion after corrosion, which can keep the original target size remaining. Then through closed operation, do corrosion after expansion. Closed operation is aimed at populating the tiny holes in the target, connecting nearby objects and smoothing the target boundary. It will not change the area obviously.

The segmentation results for adhesive target using mathematical morphology method are as follows:

(a) Adhesive target (b) Mathematical morphology segmentation image

Figure 4. Segmentation of adhesive target using mathematical morphology.

The corrosion and expansion method using mathematical morphology is easy to realize. Observing the segmentation results, we can see that this method separate target and interference successfully and obtain a better segmentation result.

5. Conclusion

According to the characteristics of the infrared image in this article, we use the snake active contour model to overcome the disadvantages such as unclosed edge image boundary, incomplete and incorrect segmentation etc. At the same time, the method is simpler than the other traditional image segmentation method. We use the mathematical morphological corrosion expansion segmentation, which is simple and effective.

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References

[1] Otsu, A threshold selection method from gray-level histograms, IEEE Transactions on Systems Man & Cybernetics 9(1) (1979), 62-66.

[2] J. ZH. Liu and W. Q. Li, Automatic thresholding using the Otsu algorithm based on the two-dimensional gray image, Acta Automatica Sinica 19(1) (1993), 101-105.

[3] Xin Li, Infrared image segmentation based on the combination of morphological and two-dimensional Otsu method, Electronic Design Engineering 21(17) (2013), 138-140 (in Chinese).

[4] Rong Wang and Xiaogang Yang, A image segmentation method of target adhesion, Journal of People's Public Security University of China (Science and Technology) 19(1) (2013), 54-59 (in Chinese).

[5] Yuanyuan Cui and Xiangang Jiang, Research on the adhering segmentation based on the local distribution characteristics of cell image, Journal of China Jiaotong University 26(2) (2009), 52-56 (in Chinese).

[6] Lin Li, Huanzhang Lu, Shanzhu Xiao et al., Touched object segmentation based on partial projection, Video Engineering 37(11) (2013), 203-205 (in Chinese).

[7] S. Liu, S. Hu, Y. Xiao et al., Bayesian shearlet shrinkage for SAR image de-noising via sparse representation, Multidimensional Systems and Signal Processing 25(4) (2014), 683-701.

[8] S. Liu, J. Zhao, P. Geng et al., Medical image fusion based on nonsubsampled direction complex wavelet transform, International Journal of Applied Mathematics and Machine Learning 1(1) (2014), 21-34.

[9] L. Li, J. Gao and H. Ge, A new face recognition method via semi-discrete decomposition for one sample problem, Optik-International Journal for Light and Electron Optics 127(19) (2016), 7408-7417.

[10] L. Li, H. Ge and J. Gao, Maximum-minimum-median average MSD-based approach for face recognition, AEU-International Journal of Electronics and Communications 70(7) (2016), 920-927.

[11] J. Gao and L. Xu, A novel spatial analysis method for remote sensing image classification, Neural Processing Letters 43(3) (2016), 805-821.

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