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Research on Infrared Image Segmentation Method for Electrical Equipment

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Abstract. Infrared Thermography(IRT) plays a very important role in monitoring and inspecting thermal defects of electrical equipment without shutting down. This paper analyzes two methods on the infrared image gray pretreatment. According to the noise types and characteristics of the infrared image, this paper uses the denoising method that based on wavelet transform and mean filter, it effectively suppresses the image noise signal. Compared with the traditional segment method, the improved GAC model has no problem of image edge fracture while segmenting images. And the experiment indicates that the improved GAC model solves the problem that the GAC model always remains in the local minimum while segmenting images which lead to unsatisfactory or unsuccessful segmentation.

Introduction

The normal operation of power equipment has a significant impact on the reliable power supply of the power grid, according to statistics, 90% of the power system accidents are caused by electrical equipment failure, and half of the faulty electrical equipment in the early stage of the performance of abnormal fever symptoms. Therefore, the monitoring of the operation status of power equipment, fault diagnosis and timely maintenance is getting more and more attention. Infrared thermal imaging technology refers to the infrared thermal imaging device to collect the surface of the object heat radiation, and then collected information on thermal radiation for further analysis, conversion, and finally the formation of infrared images on the computer. So that the technical staff will be able to clearly understand the target object surface temperature distribution.

Infrared sensor will receive infrared radiation of the measured object, but also by a lot of non-detection target infrared radiation information, so the collected infrared image will inevitably have noise, the contrast is not high, edge blur and so on. Therefore, we need to enhance the infrared image of power equipment and segmentation processing.

Substation Infrared Image Preprocessing

According to the characteristics of IR image, the noise of IR image mainly includes Gaussian noise originating from background clutter and white noise originating from shot noise and radiated noise, that is, the noise of IR image is Gaussian white noise. In the infrared image recognition process, these noises will not only affect the quality of the subsequent image segmentation, but also the target feature extraction and recognition of adverse effects. In addition, the infrared image there is still a lack of contrast defects. In order to reduce the influence of noise and improve the contrast of the image, it is very necessary to preprocess the infrared image.

Infrared Image Noise Processing Based on Wavelet Transform and Mean Filter. The section headings are in boldface capital and lowercase letters. Second level headings are typed as part of the succeeding paragraph (like the subsection heading of this paragraph).

Mean filtering is a method of replacing the pixel value with the average of the gray value of all the pixels in a pixel neighbourhood. This method, also known as neighbourhood averaging, is a linear filtering method.

Suppose that the input image is f (x, y), which is an M × N matrix and h (x, y) is a low-pass impulse response, L × L matrix. The low-pass output after convolution is Order matrix.

$$g(x,y)=\sum_{m=0}^{L}\sum_{n=0}^{L} f\left(x+m-\frac{L}{2}, y+n-\frac{L}{2}\right)\times h(x,y) \tag{1}$$

Low-pass impulse response can be selected according to the needs of the template: four neighbourhood templates, eight neighbourhood templates, 5 × 5 or 7 × 7 scale neighbourhood template. Taking into account the problem of computing speed, we can select the Gauss template processed into a horizontal template and a vertical template multiplied by the form. All the pixels in the image and the surrounding 8 points to do the average operation, so you can remove the more dramatic changes in pixels, the elimination of noise, but at the same time the image will have different degrees of blur.

$$h=\frac{1}{16}\begin{pmatrix}1 & 2 & 1\\ 2 & 4 & 2\\ 1 & 2 & 1\end{pmatrix}=\frac{1}{4}\times\begin{bmatrix}1\\ 2\\ 1\end{bmatrix}\times\frac{1}{4}\times\begin{bmatrix}1 & 2 & 1\end{bmatrix} \tag{2}$$

Wavelet transform is a very useful tool for image analysis. In essence, it is a signal with a different scale of the band-pass filter, the signal decomposed into different frequency bands on the analysis and processing.

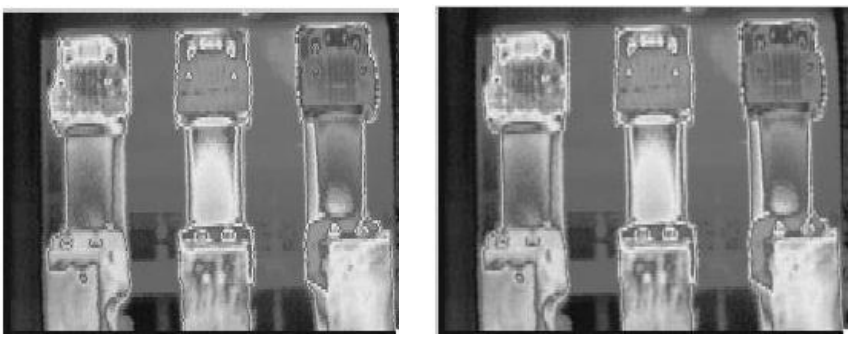
Image denoising using wavelet packet is generally carried out according to the following steps:

(1) Wavelet packet decomposition of the image. Then, the wavelet packet decomposition is performed. Then, the wavelet packet decomposition of the wavelet packet is performed.

(2) Determine the optimal wavelet packet base. Ie, for a given entropy criterion, the optimal tree is calculated.

(3) Threshold quantization of wavelet packet decomposition coefficients. For each wavelet packet decomposition coefficient, an appropriate threshold is selected and the coefficients are quantized.

(4) Wavelet packet reconstruction. The wavelet packet is reconstructed according to the wavelet packet decomposition coefficient of the lowest layer and the coefficients after quantization.



(a) original image (b) filtering denoising

Figure 1. De-noising of infrared image

Contrast Enhancement of Infrared Image. The object and background of the infrared image are poor in contrast to the visible light image, and the spatial correlation of the pixels in the image is relatively good. The mean gray value of the image is relatively stable and the variation of variance is small. In this section, according to the characteristics of infrared images, histogram equalization method is used to enhance the image contrast.

A histogram is a statistical result of the number or frequency of gray values of each pixel in an image, which reflects the frequency of different gray values in the image. For the eight-bit grayscale image, there are 256 gray levels, but the actual gray scale of the original image after digitization often does not occupy all the gray levels of 0-255, but concentrated in a certain area, Gray information of a waste, but this time the image contrast is relatively poor. Histogram equalization is a point operation that changes the gray value of an image point by point so that each gray level has the same number of pixels as possible, that is, the histogram tends to balance. The calculation steps of this method are as follows:

Given that the image has L-level gray scale (0,1, ..., L-1), n is the number of pixels in the image, ni is the number of pixels in the i-th gray scale, the occurrence frequency of the k-th gray scale is:

$$P(k)=\frac{n_k}{n} \tag{3}$$

The histogram transform function can be obtained:

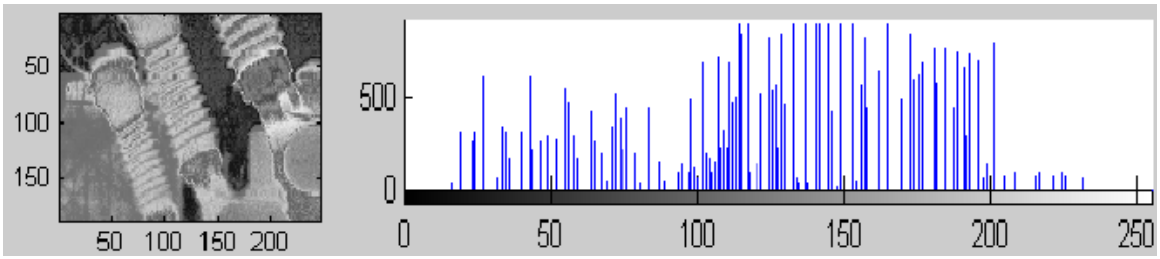
$$H(k)=\sum_{i=0}^{k}\frac{n_i}{n}=\sum_{i=0}^{k}P(i) \tag{4}$$

The gray level of the k-th gray-scale pixel after the histogram equalization is:

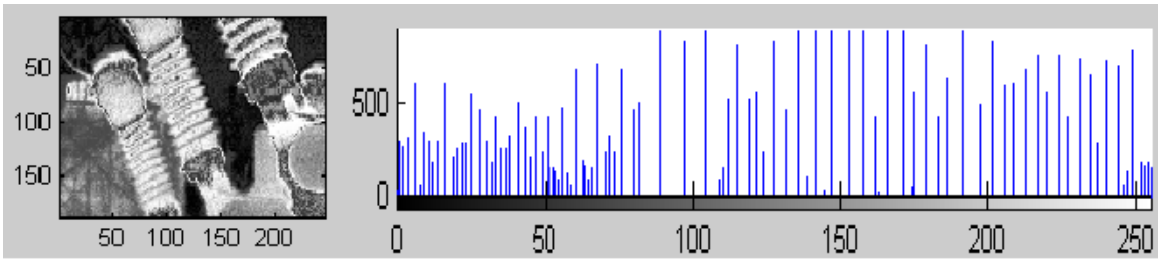
$$t_k=L\times H(k) \tag{5}$$

Where k = 0,1, ..., L-1.

The results of histogram equalization are shown in the following figure. In the following figure, the contrast of the original image is very weak because the gray scale is distributed over an interval. Histogram equalization approximates the uniform distribution by mapping gray values, improving contrast.



(a) The original image and its histogram



(b) the equalized image and its histogram

Figure 2. Histogram of infrared image

Infrared Image Segmentation Method of Power Equipment Based on Partial Differential Equatio

The basic idea of the active contour model is to transform the image segmentation problem into an evolutionary problem (curve shrinkage or dilatation) of a closed curve C (p), so that the curve finally stays at the edge of the image. This process can be minimized by minimizing the closed curve C (p) energy function to achieve:

$$E\left[C(p)\right]=\alpha\int_0^1\left|C_p(p)\right|dp+\beta\int_0^1\left|C_p(p)\right|^2dp-\lambda\int_0^1\nabla u\left|C_p(p)\right|dp \tag{6}$$

GAC Model for Infrared Image Segmentation of Electrical Equipment. The GAC model defines the following energy function and determines the active contour by minimizing its energy value:

$$L_R(C)=\int_0^{L(C)}g\left(\left|\nabla u\left[C(s)\right]\right|\right)ds \tag{7}$$

In the Eq.7, LR (C) represents the "weighted arc length", and the integral upper limit L (C) represents the geometric arc length of the curve C. The above function is based on the inherent parameter of the arc length of the curve, Does not depend on other free parameters, and thus does not depend on the free parameters as in the classical contour model.

The gradient descending flow corresponding to Eq.7 is minimized:

$$\frac{\partial C}{\partial t}=g\left(\left|\nabla u\right|\right)k\vec{N}-\left(\nabla g\cdot\vec{N}\right)\vec{N} \tag{8}$$

The generalized GAC model is:

$$\frac{\partial C}{\partial t}=g\left(\left|\nabla u\right|\right)(k+m)\vec{N}-\left(\nabla g\cdot\vec{N}\right)\vec{N} \tag{9}$$

In the formula, m is a constant rate. The introduction of gmN can not only accelerate the rate of the curve C (t) shrinking toward the target boundary, but also ensure that the curve C (t) does not stay in a local Minimum state.

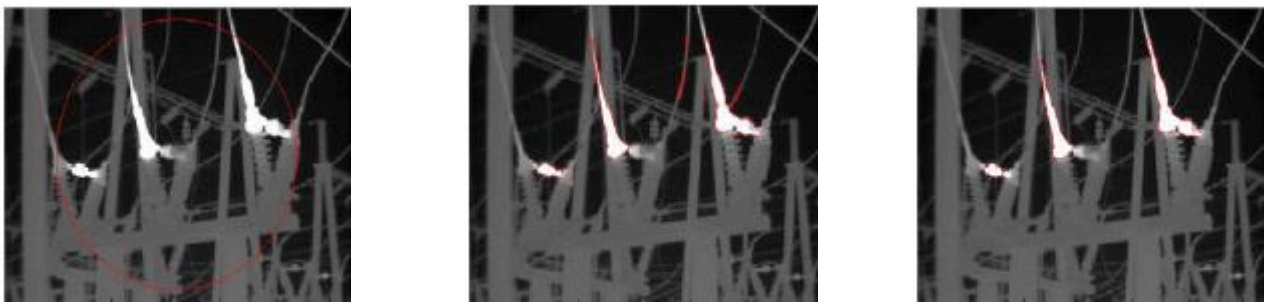
Improvement of GAC Model. In the generalized GAC model, the gmN term is introduced, and the constant rate m is any constant selected by human. The selection of m has a great influence on the result of segmentation simulation. The selection of irrational constant m often leads to the problem of boundary penetration, Resulting in the image segmentation is not ideal or failed.

In this paper, the adaptive evolution rate m (D) is given as the following:

$$m\left(\bar{D}\right)=\begin{cases}\dfrac{\sqrt{\bar{D}_{\text{int}}+\rho}}{L} & \bar{D}_{\text{int}}>\bar{D}_{ext}\\ 0 & \bar{D}_{\text{int}}=\bar{D}_{ext}\\ \dfrac{\sqrt{\bar{D}_{ext}+\rho}}{L} & \bar{D}_{\text{int}}<\bar{D}_{ext}\end{cases} \tag{10}$$

Where $\bar{D}_{\text{int}}$ is the mean value of the gradient of the internal image of the evolution curve, $\bar{D}_{ext}$ is the mean value of the gradient gradient of the external image of the evolution curve, ρ is the adjustment parameter, and L is the control parameter to control the evolution rate of the speed.

The modified GAC model automatically determines the evolution speed $m\left(\bar{D}\right)$ by the position of the evolution curve, and gives the exact value of $m\left(\bar{D}\right)$. It solves the blindness of the value of parameter m in the generalized GAC model. In the following, infrared image segmentation detect whether the improved GAC model can achieve the theoretical effect.



(a) Original contours (b) GAC model (c) Improved GAC model

Figure 3. Contact segmentation

Conclusions

The GAC model is a partial differential equation model proposed for the defect of the active contour model. However, the GAC model has its own shortcomings. In this paper, the GAC model is applied to the image segmentation problem. The improved GAC model is applied to the infrared image segmentation of power equipment.

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