Research on a method of X - ray graph analysis for power equipment

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Abstract. The digital X-ray imaging detection technology is becoming more and more efficient and high-precision. X-ray digital imaging detection has been widely used in the quality detection, defect assessment and other technical fields of power equipment. At present, there is no unified image processing software in the electric power industry, and the software provided by detector manufacturers only covers basic functions, and there are many problems to be solved, such as no image quality judgment, image contour fitting, distortion correction and other core functions. Therefore, this paper proposes a kind of X-ray detection prevention for power equipment, which can provide the standardized determination of image quality and realize a variety of image processing functions.

Keywords: Power equipment, X-rays, image processing.

1. Introduction

The basic principle of X-ray detection: using the attenuation characteristic of X-ray propagation in the medium, when the X-ray with uniform intensity is generated and emitted from one side of the tested equipment, the defect location and the tested equipment base. Because of the different attenuation characteristics of the body material to the X-ray, the X-ray intensity after passing through the inspected equipment will no longer be uniform. The X-ray intensity after passing through the inspected equipment can be determined by using the imaging equipment on the other side to detect the remaining X-ray intensity. Whether there are defects on the backup surface or inside, and the type and nature of defects can be determined according to the generated X-ray images. The advantages of X-ray detection are as follows: the detection results are intuitive; It is easy to qualitatively and convenient to quantitatively locate defects. Detection results are easy to save: a wide range of applications. Of course, X-ray detection also has certain limitations: the detection cost is high; Security risks exist. Pay attention to X-ray protection: The X-ray penetration capability of large devices is limited. This paper presents an X-ray imaging analysis method for power equipment. The main function of this method is to determine the quality of the X-ray image of power equipment and to process the image accordingly. After the method is put into use, on the one hand, there is a unified standard for the quality determination of X-ray imaging of power equipment, which is not affected by subjective factors such as the experience of on-site inspection personnel. On the other hand, by using this method, field inspectors can not only clearly adjust the detection process and improve the efficiency of their field work, but also objectively judge the defects of power equipment through the image processing function, so as to inform the substation staff to deal with them in time [1-2].

2. X-ray image processing technology

In recent years, with the rapid development of mathematics, computer and artificial intelligence technology, new image processing methods continue to emerge, and new algorithms are constantly developing new tools and operators, trying to eliminate image noise as much as possible, enhance image detail quality and multi-scale detection feature edge, such as mathematical morphological method, wavelet transform method, neural network method and so on [3-4].

1.mathematical morphological method, is that the algorithm is to extract the image component useful for the expression and description of the area. Corrosion and expansion are the basis of morphological processing, opening and closing are two important operations of morphology, and hit

or miss transformation is the basic tool of morphological shape detection. The most attractive aspect of the method is the extensive set theory basis developed by morphological techniques.

2.wavelet analysis, wavelet analysis is a mathematical tool for all kinds of image processing has a good effect, can get the details of the signal at different scales. Wavelet analysis, because of its unique multi-scale time-frequency analysis ability and local feature extraction ability, as well as the characteristics of multi-resolution, makes people have a strong interest in wavelet transform technology, which is widely used in various fields of image and signal processing, and has become one of the essential and effective means in image analysis and processing.

3. Neural network method. In recent years, neural network is a kind of signal and image processing tool which is popular and studied more. Its working principle is as follows: Firstly, select a neural network method according to the problem to be solved with certain prior knowledge, and then train it until its process converges. Neural network has the ability to learn, and can develop the knowledge even beyond the level of the designer.

The acquisition of image data information and the primary image processing technology has been relatively mature, can solve most of the needs of the primary image processing, but the advanced image processing function is still a certain degree of difficulty, for the different nature of the image of the corresponding advanced processing algorithms are also very different.

3. X-ray image algorithm for power equipment

X-ray digital images are generally characterized by low image contrast, unclear defect and image ontology edge, and large amount and type of noise. Many adverse factors not only affect the analysis and evaluation of the nature and type of defect in X-ray images, but also bring a lot of trouble to the next step of image processing (stitching, defect extraction and other advanced processing). Therefore, it is necessary to reduce the noise and improve the image contrast [5-6].

In this paper, the quantum noise of the system is first converted into Gaussian white noise, and then the image is denoised by the improved non-local average algorithm based on sobel gradient information.

The main reason of image degradation in X - ray imaging system is the random noise. As mentioned above, the generation process of X-rays and the imaging process of X-ray penetration detection are Poisson stochastic processes in both time and space, then:

$$P(n) \approx \frac{m^n}{n!} e^{-m}$$

When n is large, the calculation error based on the Poisson distribution formula is very complicated and inconvenient in practical application. Therefore, this paper adopts the Stiling approximation formula for the noisy image to convert Poisson noise into Gaussian white noise. The following conversion relationship exists between the two.

$$n! \approx \sqrt{2\pi n} n^b e^{-n}$$

Converted into Gaussian distribution:

$$p(n) = \frac{1}{\sqrt{2\pi n}} e^{\left[-\frac{(m-n)^2}{2m}\right]}$$

Then, the noise model of X-ray digital image can be converted into:

$$v(i) = u(i) + n(i)$$

Among them: $v(i)$ is for X-ray digital image, $u(i)$ is the ideal ray digital image, $n(i)$ is the background noise. For Gaussian white noise, there is:

$E\left\|v(N_i)-v(N_j)\right\|_{2a}^2 = E\left\|u(N_i)-u(N_j)\right\|_{2a}^2 + 2\sigma^2$ Among them, $\left\|v(N_i)-v(N_j)\right\|_{2a}^2$ Is the Gauss weighted Euclidean distance in pixel (i,j) field based on gray scale,a>0 is the standard Gaussian convolution kernel.

The non-local average filtering algorithm can make full use of the redundant information in the X-ray digital image for denoising. The filtering process is not simply to compare the gray value of a single pixel in the image, but to compare the distribution of the whole gray value around the pixel, and select the weight according to the similarity degree of the gray value distribution of the image. In general, NL algorithm can be used directly to reduce the noise of X-ray digital images.Suppose v is the image with noise reduction, u is the X-ray detection image, n is the mean is 0 and the variance is additive noise of δ^2, then:

$$NL(v)(x) = \frac{1}{C(x)}\int e^{\frac{(G_a|v(x+)-v(y+)|^2(0))}{h^2}} v(y)dy$$

Where h is the filtering parameter, G_a is the Gaussian kernel of a by standard.

For digital images, the set of pixels $v = v(i)(i \in I)$ and I, then the expression of algorithm NL is:

$$NL(i) = \sum_{j\in I} w(i,j)v(j)$$

Where the weight is:

$$w(i,j) = \frac{1}{Z(i)} e^{\left(-\frac{\left\|v(N_i)-V(N_j)\right\|_{2a}^2}{h^2}\right)}$$

$$Z(i) = \sum e^{-\frac{\left\|v(N_i)-V(N_j)\right\|_{2a}^2}{h^2}}$$

Where, $\left\|v(N_i)-V(N_j)\right\|_{2a}^2$ is the Gauss weighted distance of gray level in the two fields of pixel i and j.

Non-local average filtering algorithm is obviously superior to other common image denouncing algorithms in denouncing effect and preserving image details. The non-local average filtering algorithm is a kind of neighborhood filtering algorithm and a generalization of neighborhood filtering algorithm. Its weight is obtained according to the similarity of the gray distribution of the whole region around the pixel. It has a strong ability to maintain the spatial resolution of the image while reducing the image noise.

When the traditional NL algorithm is used to process complex images, it has a large amount of computation and slow processing speed, especially when the processing of large images, this problem is more prominent. In addition, this method will introduce artificial artifacts into the smooth area of the image, and the image will become fuzzy, and the spatial resolution of the image will be affected. In order to solve the above problems, this paper improves the traditional NL-means method. Firstly, histogram equalization algorithm is used to equalize the image, and sohel operator is used to introduce the gradient information of the image. In this way, the correlation between pixels in the image neighborhood can be effectively reduced, and artificial artifacts can be effectively reduced. The details of the image are preserved without blurring. At the same time, the complexity of the original NL-means denoising algorithm is reduced and the calculation time is saved, so as to adapt to the detection needs of industrial production tasks [7-8].

4. Experiment and Analysis

Power equipment X-ray image quality determination and preprocessing system test in strict accordance with the test process, right

The system has been thoroughly tested. This section mainly analyzes the image processing speed of the test system, that is, when the system is running Intertest, and the accuracy of image distortion correction.

Among the three types of image databases designed and implemented by the system, there are 82 class I tensioning clip images, 61 class II tensioning clip images and 73 GIS images. For each type of image, the system can realize three kinds of image processing: image enhancement, image contour fitting and image distortion correction. Among them, image distortion correction is only used for GIS images. From the algorithm theory, the algorithm can be classified as the matrix calculation of gray matrix. Therefore, the image processing speed is mainly related to the size of the image gray matrix, that is, to the image resolution. In system test, this section tests the program running time of image processing algorithm in the system on different resolutions and different categories of images in the image database, so as to investigate the system processing speed under different images. Record the correlation results of the average running time of each type of image at the corresponding resolution

Table 1. The running time of the image processing program

Type of algorithm	Category of image	2984*2448	1492*1224
Enhancement of image	Type I	869	204
	Type II	839	199
	GIS	948	233
	Average	885	212
Fit of contour	Type I	456	118
	Type II	799	156
	GIS	534	123
	Average	596	132

As can be seen from the table, for image enhancement algorithms, program running time increases linearly with the increase of image resolution, and has little correlation with image categories. The average running time of the three types of images increases from 17ms corresponding to 373 x 306 images to 885ms corresponding to 2984 x 2448 images with the resolution, but the processing time is kept within 1s, indicating that the image enhancement module has a fast running speed and high efficiency.

For image contour fitting algorithm, the program running time increases linearly with the increase of image resolution, but the growth rate is slower than that of image enhancement algorithm. The average running time of the three kinds of images increases from 18ms corresponding to 373 x 306 images to 596ms corresponding to 2984 x 2448 images with resolution. At the same time, when the image resolution is larger, the correlation between the program running time and the image category is greater. Compared with the overall gray value of the class II image and the GIS image, the difference between the overall gray value of the class II image is smaller, and the edge recognition is more difficult, so the processing time is relatively long, but the processing time remains within IS. The results show that the running time of the contour fitting algorithm is positively correlated with the image resolution and the noise amount, and it has fast running speed and high running efficiency.

Table 2. Accuracy test of GIS image distortion correction

Given the Angle of inclination	5°	6°	7°	8°	9°	10°
Algorithm recovery Angle	5°	6°	7°	8°	9°	10°
error	0°	0°	+1°	0°	+1°	+1°
Given the Angle of inclination	5°	6°	7°	8°	9°	10°
Algorithm recovery Angle	5°	6°	7°	8°	9°	10°
error	0°	0°	0°	-1°	-1°	-1°

In testing the accuracy of distortion correction algorithm, first on GIS image distortion correction, and defines the distortion Angle of 0 revised images, the step length for 1 clockwise [- 10 °, 10°], had

21 a given Angle of the image, the image distortion correction processing, And record the recovery rotation Angle required by the algorithm. If the recovery Angle of the algorithm is the same as the original given tilt Angle, the algorithm is accurate. Otherwise, it is an algorithm error. With a GIS image accuracy test cases, for example, as shown in table 1, Angle can be observed that the error of the algorithm are within the scope of the $\pm 1^{\circ}$, absolute error is very small, does not affect the observation of the corrected image recognition.

The average accuracy Angle, as shown in table 4-4, when a given Angle range of [- 6°, 6 °], the algorithm accuracy can reach more than 95% on average, when a given Angle range is [7 °, 10 °] or [10 °- and - 7 °], the average accuracy algorithm also remains within the (85%, 90%), And the absolute error basic keep within $\pm 1^{\circ}$, little impact on actual image. So when the Angle range of [- 10 °, 10°], the system choice of distortion correction algorithm with high accuracy, can effectively achieve the power equipment testing required for distortion correction effect.

5. Summary

This paper focuses on the design and implementation of X-ray image quality determination and preprocessing of power equipment. The main research contents include the following two aspects:

1. Quality determination of X-ray images of power equipment. A quality determination process suitable for X-ray images of power equipment is designed to make the whole determination process automatic, including automatic recognition of the position of the double-wire image quality meter in the image, automatic calculation of the basic resolution of the image; Normalized SNR and grayscale saturation are calculated automatically to support image quality determination.

2. Preprocessing of X-ray images of power equipment. An image enhancement algorithm suitable for X-ray images of power equipment is designed, that is, wavelet transform, gamma transform and histogram normalization are combined to enhance the image. A contour fitting algorithm suitable for X-ray images of power equipment is designed, that is, the edge detection is carried out by using Canny algorithm whose gray value mean is a high threshold, and then the contour fitting algorithm based on topological structure is used for contour fitting. A distortion correction algorithm suitable for X-ray images of power equipment is designed, that is, using Radon transform to correct the Angle of GIS images.

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