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A Method for Detecting Oil Pillow Oil Level Based on Image Processing Technology

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Abstract

According to the characteristics of over-segmentation or under-segmentation based on the current adaptive canny algorithm and the infrared image of oil-sleeve oil level, this paper proposes a new adaptive detection method. Firstly, manual selection and median filtering are used to realize the pre-processing operations such as selection and filtering of the target area; Then, Otsu's method, local adaptive threshold segmentation algorithm, morphological corrosion, etc. are used to find the complete independent maximum area in the oil drum, that is, the range in which the threshold may exist; Finally, the sobel operator is used to find the maximum value of the image gradient in the range where the threshold may exist, and then it is used as the canny threshold to realize the automatic detection of the oil level of the oil pillow. Experiments show that the proposed method can automatically detect oil level and has good robustness.

Keywords

The oil level of oil pillow; automatic detection; Image segmentation; Canny algorithm.

1. INTRODUCTION

With the vigorous development of China's economy, the power system is developing in the direction of “strong smart grid” and “ubiquitous power internet of things”, in which self-healing is an important feature [1]. Self-healing not only requires timely recovery of power supply after power system failure, but also requires detection and early warning of the operating status of electrical equipment to avoid accidents caused by hidden troubles. The oil level of the oil pillow is an important test object for electrical equipment. The level of the oil level has important safety significance for the diagnosis of the operating state of the transformer. Excessive oil level may cause oil spillage. Low oil level may cause low-load operation of the transformer or even internal flashover.

In recent years, infrared detection technology has been widely used in electrical equipment fault detection and early warning due to its advantages of non-contact, high safety, fast response, convenient operation, accurate judgment and other traditional conventional detection methods hasn’t achieved the good results [2]. Therefore, it is of great significance to study the infrared image detection of oil pillow oil level. The infrared image is obtained by "measuring" the heat radiated from the object, compared with the light image: poor resolution, low signal-to-noise ratio, and blurred visual effects. It is often necessary to perform processing such as filtering and segmentation to obtain valid information. It is often necessary to perform processing such as filtering and segmentation to obtain valid information. Since its publication in 1986, the Canny algorithm has received much attention and has been widely used, but its threshold needs to be manually adjusted.

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In [3], the adaptive segmentation of the canny algorithm was implemented with Otsu valve otsu. In [4], the gradient template in the 45o and 135o directions is added and the dichotomy search principle is used to improve the Otsu algorithm to calculate the high and low thresholds of the gradient amplitude, and a more detailed adaptive detection is realized. However, both [3] and [4] take the target object area and the background area as a whole, emphasizing the segmentation of the distinct areas, which is not suitable for adaptive processing of the infrared image of the oil pillow oil level with blurred visual effects. Therefore, this article improves it..

2. BASIC PRINCIPLES OF INFRARED DETECTION

The The Infrared light is an electromagnetic radiation produced by photons. All objects above absolute zero (-2730Cor-459.690F) will emit infrared radiation, which is why objects can be detected by infrared devices.

According to Stefan-Boltzmann's law:

$$j^{*} = \delta T^{4} \tag{1}$$

Where j^{*} is the total energy radiated per unit surface area of all wavelengths of black light per unit time, T is the blackbody thermodynamic temperature, δ is the proportional constant, which is from other Derived from the physical constants of knowledge.

The infrared image is an infrared device that captures the infrared light signal from the object and converts it into an electrical signal, which is processed by the embedded device and presented on the screen in an interpretable manner by the human eye, and the obtained object is One-to-one correspondence of thermally distributed and grayscale value. In the electrical equipment in the running state, the temperature of the electrical equipment is generally higher than the temperature of the surrounding environment, and the temperatures of different parts of the same electrical equipment are generally inconsistent, which provides the possibility of detecting the oil level of the oil pillow through infrared images.

2.1. Detection Steps

The operating state of the transformer can continuously absorb heat through the oil to cool down. Due to the heat conduction effect, the oil pillow will form a significant difference with the surrounding environment. In the narrow space of the oil pillow, the oil surface is not very clear, but the oil surface is the whole The place where the rate of change in the oil pillow is the largest, according to which the oil level of the oil pillow can be found.

The flow chart of the oil pillow oil level detection step is shown in Figure 1:

2.2. Collecting Oil Pillow Oil Level Image

Capture good quality images.

Try to select a better position and direction to collect the image, which lays a good foundation for the subsequent image processing.

2.3. Image Preprocessing

The image of the image oil pillow object area is manually selected, and then denoised by median filtering. The artificial frame selects the object area to be observed to minimize the interference of other electrical equipment. The main idea of median filtering is to scan each pixel in the image sequentially with a "window" and look at neighboring pixels in its vicinity, replacing its value with the median of its region. It also preserves good edge information while removing noise. The median filter can be expressed as:

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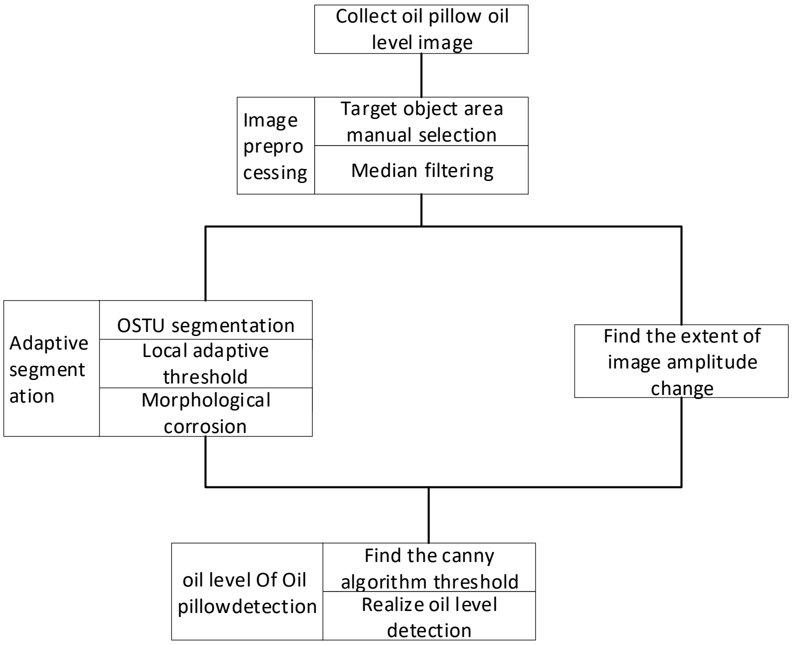

Figure 1. Flow chart of oil pillow oil level detection steps

$$R_{pq} = \underset{L}{med}\{l_{pq}\} \tag{2}$$

Where L is the filtering window; pq is the label of a pixel in the image; med is the median value of the arrangement within the L window centered on a pixel marked with pq.

2.4. Adaptive Segmentation

In the target object area, in order to deal only with the target object of interest, this article uses the Otsu method to remove the background. Then, through the local threshold adaptive segmentation method, the region in the oil pillow that changes slowly with respect to the oil surface is obtained. Then, in order to improve its accuracy, it was etched using a morphological method. Finally, the contour search method can extract the largest area in the oil pillow that changes slowly with respect to the oil surface.

This article removed the background and chose the Otsu method. The algorithm assumes that the image contains two types of pixels according to the bimodal histogram (foreground pixels and background pixels), so it calculates the optimal threshold that can separate the two classes such that their inter-class variance is the greatest variance. The variance between classes can be expressed as:

$$\sigma_b^2(t) = \omega_0(t)\omega_1(t)[\mu_0(t) - \mu_1(t)]^2 \tag{3}$$

Where the weights ω_1 and ω_2 are the probabilities that the image pixel values are separated into two categories by the threshold t; μ_0 and μ_1 are the average values of the two classes; σ_b^2 represents the inter-class variance; and the maximum inter-class variance can be obtained by continuously exhausting the search. That is the optimal threshold. In order to achieve self-adaptation, the Otsu method was adopted. When the image is acquired, the area of the oil occupant may be approximated by the background due to the angle and position. This

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causes mis-segmentation, but it does not affect the segmentation result, which further proves the robustness of the proposed algorithm.

A relatively gentle region can be obtained by the local threshold adaptive segmentation method. The principle of local threshold adaptive segmentation method can be expressed as:

$$dst(x,y)=\begin{cases} maxValue & src(x,y)>T(x,y) \\ 0 & otherwise \end{cases} \tag{4}$$

Where $T(x,y)$ is a threshold calculated separately for each pixel, which is equal to the average value of $blockSize \times blockSize$ in the region minus an additional value C. In this paper, $blockSize$ takes 1/10 of the smallest side of the largest inscribed rectangle of the oil pillow portion. Of course, other values can also be taken. As long as the corrosion in the next step is ensured, the area with the largest area divided in the oil drum accounts for about 1/2 of the undivided area, which ensures that the information including the relatively flat area is independent without losing contact with the segmentation target - the oil surface.

The local threshold adaptive segmentation method is to divide the image into local parts. It is inevitable that there will be one isolated point or a relatively steep area, so this paper uses the morphological method to Corrosion was carried out. Corrosion can be expressed as:

$$A\Theta B=\{z\,|\,(B)_z \cap A^c=\varnothing\} \tag{5}$$

Where B represents a structural element, A is a complement of the target object pixel of an image, $\varnothing$ is an empty set, and z is a set of all points z contained in A with a translated Z.

Because in the manual frame selection, it will inevitably contain other electrical equipment or a part thereof, but it also implicitly provides a message that the observed object accounts for most of the area of the frame selection, and the oil pillow is morphologically corroded. The largest area again occupies a larger area of the target object. In order to extract the largest area after corrosion in the oil pillow, this paper uses contour detection extraction. The principle of contour detection can be expressed as:

$$\begin{cases} f(i,j)\text{Is the starting point of the outer boundary} & f(i,j-1)=0 \quad \text{and} \quad f(i,j)=1 \\ f(i,j)\text{Is the starting point of the empty boundary} & f(i,j)\geq 1 \quad \text{and} \quad f(i,j+1)=0 \end{cases} \tag{6}$$

2.5. Find the Degree of Image Amplitude Change

The sobel operator is used to calculate the degree of change in image amplitude.

The median filtered image is used to calculate the degree of change using the sobel operator. The Sobel operator can be expressed as:

$$G_x=\begin{bmatrix} -1 & 0 & 1 \\ -2 & 0 & 2 \\ -1 & 0 & 1 \end{bmatrix} \qquad G_y=\begin{bmatrix} -1 & -2 & -1 \\ 0 & 0 & 0 \\ 1 & 2 & 1 \end{bmatrix} \tag{7}$$

Sobel operator in the x direction sobel operator in the y direction

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2.6. Realize Oil Level Detection

3.4 and 3.5 respectively obtained the degree of change of the maximum area and the target object area after corrosion in the oil pillow, so that the maximum degree of change of the target object in the largest area after corrosion can be obtained, that is, the sobel calculation of the largest area after corrosion is obtained. The maximum value of the amplitude change. It is used as the minimum threshold calculated by canny, and the maximum threshold of canny is 1.5 times, which can realize oil level detection. The infrared image of this paper is obtained by a better infrared camera, and the above mentioned median filtering has been used, so the noise has been removed, and the Maximum amplitude value of the original grayscale image in the region with the largest area after corrosion is calculated by the sobel operator. If it is more accurate, the histogram can be used to count the maximum gradient of the region of the original grayscale image after the corrosion, and a threshold is set. When the threshold is smaller than the threshold, the maximum value is removed. When it is greater than or equal to this value, this maximum value can be taken. The maximum value that is often taken relative to the canny operator is 2 to 3 times the minimum value. Because the transformer oil pillow area is small and the gradient changes slowly in the infrared image of the transformer oil pillow, we change the ratio of the maximum value to the minimum value. 1.5. The amplitude G in the canny algorithm can be expressed as:

$$G = \sqrt{G_x^2 + G_y^2} \tag{8}$$

3. TEST RESULTS AND ANALYSIS

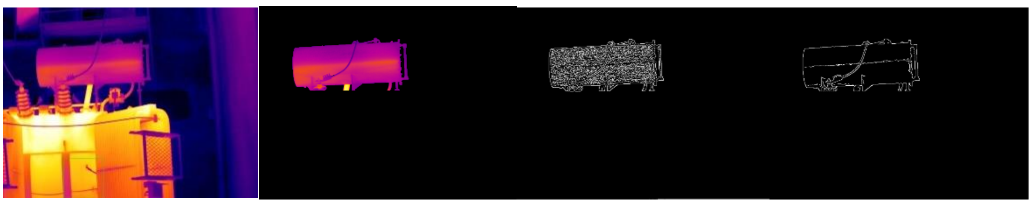
The method described in this article is verified on the platform built by VS2015 and opencv3.4.0. All programs are written in C++.

Figures (a1), (a2), (a1), and (a3) are original views, and (a2) is a part of the figure (a1).

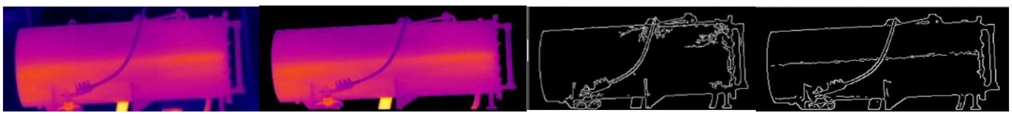
Figures (b1), (b2), (b3), and (b4) are the pictures after the background is removed, where (b1) is to verify that the algorithm removes the background by other methods, and has no effect on the final result.

Figures (c1), (c2), (c2), and (c4) are segmentation diagrams using the algorithm of Reference [3].

Figures (d1), (d2), (d2), and (d4) are divided views using the present method.



(a1) Front oil pillow oil level (b1) Extract object (c1) canny (d1) test algorithm



(a2) Front oil pillow oil level (b2) Extract object (c2) canny (d2) test algorithm

Figure 2. Verification of the same object in different size backgrounds

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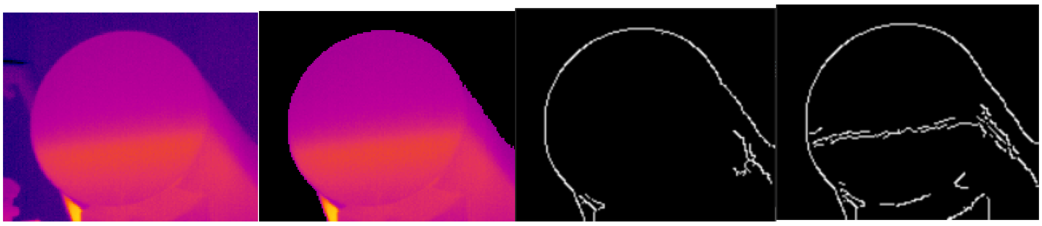
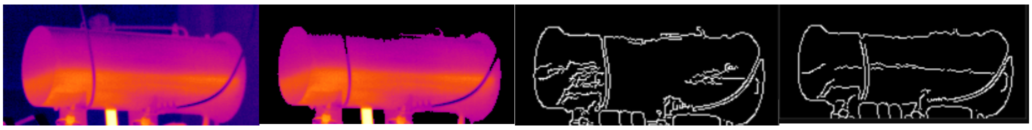
Reference [3] divides the target object and the background as a whole, and it is inevitable to be interfered by external information. The conditions required for segmentation of the method proposed in this paper are derived from the internal information of the target object, so environmental factors have less influence on it.



(a3) Oil pillow oil level side (b3) Extract object (c3) canny (d3) test algorithm



(a4) Front oil pillow oil level (b4) Extract object (c4) canny (d4) test algorithm

Figure 3. Verification of the algorithm from different orientations in accordance with the parameter settings in Figure 2.

The required parameters in this paper are calculated from the image or according to the image, and the method is more appropriate. For example, the area with the largest area of the oil barrel in the next step of corrosion is about 1/2 of the undivided area. The independent information of the relatively flat area does not lose the connection with the segmentation target - the oil surface. Therefore, it has good robustness.

4. CONCLUSION

(a) The solution proposed in this paper can work in more complicated environments.

(b) The algorithm proposed in this paper can effectively detect the oil level of the oil pillow.

(c) The proposed algorithm is robust and adaptive.

(d) The algorithm for the online segment link and the elimination of the isolated point in this book needs to be improved.

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