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Infrared Image Segment and Fault Location for Power Equipment

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Abstract. Infrared imaging technology relies on the characteristics of non-contact, high fault diagnosis efficiency, intuitive and accurate data, night monitoring, high equipment sensitivity, strong environmental adaptability, etc., and has become a very important tool in the field of online real-time monitoring of power system. This paper introduces the application of image segmentation in power system fault detection using infrared image, divides the image into fault area and non-fault area, realizes the recognition and location of equipment fault area, and introduces several methods of mainstream image segmentation. In this paper, the application of infrared image segmentation in fault maintenance of power equipment is discussed in detail by taking the fault location of electrical insulator as an example, and the segmentation methods are compared.

1. Introduction
The requirements of the society on the stability and reliability of electric power make the periodic overhaul of traditional electric power equipment no longer adapt to the development of the electric power industry. Along with the continuous development of the infrared detection technology and the rapid promotion, power equipment failure or hidden dangers can be found more timely, thereby reducing the energy loss caused by power equipment failure, and economic losses, reduce the probability of power equipment accident, fully improve the reliability and security of power system.

The development of image segmentation technology provides a direction for the fault localization of infrared image[1,2]. In the past 40 years, a total of thousands of algorithms have been proposed, the most common of which are threshold segmentation method and edge detection method [3,4]. The threshold segmentation method includes histogram threshold method[5,6]. The classical algorithms in edge detection include canny algorithm[7], robsel algorithm[8], sobel algorithm[9] and prewitt algorithm[10,11]. In this paper, these image segmentation algorithms are used in the infrared image of electrical equipment, and the normal and abnormal parts of the infrared image are separated to achieve the effect of fault segmentation and localization.

In this paper, Firstly, the principles of threshold segmentation and edge segmentation are introduced. Secondly, the algorithm is compared with the experimental results and analyzed. Through the interrelation between temperature and gray value, the fault temperature of power equipment is inquired and set as the gray threshold of the gray image of power equipment. The gray image is processed by using the algorithm proposed in this paper. Finally, the result of the segment methods are discussed.

This paper is organized as follows. The segment methods is introduced in Section II. Experiments and results is explained in Section III. Finally, Section IV concludes this paper.
2. The Methods

So-called image segmentation is image segmentation into several regions, each region has its own unique properties different from other area, in these areas are then separated extracts containing the target area for image, the image itself has a complex background environment and various interference, extracted from the image information of the target, you need to use the means of image segmentation in the infrared image processing and analysis steps, you will first need to the infrared image preprocessing, the next step is image segmentation, finally is image recognition. To analyze the image, must after image processing, image segmentation, extraction and separation of different areas, the analysis of the image in the actual technology of image processing, image segmentation, the infrared image is all involved analysis of infrared image of target extraction and detection methods such as necessary process in the current image segmentation methods, the commonly used method of threshold segmentation and edge segmentation.

2.1. Threshold Segmentation

The so-called image segmentation is to divide the image into several regions, each region has its own unique characteristics different from other regions, and then separate and extract the regions containing the target in these regions. For infrared image, the image itself has complex background environment and various interferences. To extract the target information from such image, image segmentation is needed. In the process of infrared image processing and analysis, it is necessary to preprocess the infrared image first, then image segmentation and finally image recognition. To analyze the image, it is necessary to segment the image after image processing, extract and separate different regions, and analyze the image. Among the practical techniques for image processing, image segmentation of infrared images is a necessary process involving extraction, analysis and detection of targets in infrared images.

In the current image segmentation methods, the more common methods are threshold segmentation and edge segmentation.

Image segmentation with threshold is a very simple image segmentation method. When the background gray level and the target gray level are at two levels, the threshold method can be used to segment the image conveniently. The basic principle of threshold segmentation is to classify the pixels of an image into several categories by setting different thresholds. In fact, it transforms the input image \( f(x,y) \) into the output image \( g(x,y) \) by setting the threshold value \( T \). The specific transformation formula is as follows:

\[
g(x,y) = \begin{cases} 
1 & f(x,y) \geq T \\
0 & f(x,y) < T 
\end{cases}
\]

Where \( g(x,y) \) is the gray value of \( (x,y) \) points after image processing, \( f(x,y) \) is the gray value of \( (x,y) \) points before image processing, and \( T \) is the set threshold.

It can be found that the key point of threshold segmentation algorithm is to determine the gray threshold. In order to accurately segment the target and background of the image, it is necessary to choose a very appropriate gray level with it.

Here we will use a commonly used methods for threshold segmentation: histogram threshold method

2.1.1. Automatic threshold method. Automatic threshold method is an adaptive threshold determination method proposed by the Japanese scholar OTSU in 1979. Its principle is: For the infrared image, we focus on what you need, also is the goal, in the image of other information can be attributed to the background, then, the infrared image is divided into two parts: the background and the target in the vast majority of cases, the target and background are in grayscale of different target and background difference, the greater the then we are more easy to read the target information from image and we are used to represent the variance between target and background difference, namely the
variance between target and background difference with the class into positive correlation. When part of the background of fault can be divided into target, or we focus on the goal of the part is wrong is divided into background leads to the difference of background and target smaller, therefore, if there is a kind of image segmentation method makes the maximum variance between, then this method causes the probability of wrong points must be the smallest, is the target and background is the most accurate.

2.2. Edge Segmentation
Another important method of image segmentation is edge detection. Edge operator is one of the most commonly used edge detection methods. There are Roberts operator, Sobel operator, Prewitt operator, etc. These operators are based on partial differential estimation. The sudden change of gray level at the edge means that the first derivative of the point on the edge of the image is the largest, and the second derivative is equal to zero. Using differentiation, we can figure out these points in the image, and the lines formed by these points are the edges of the region. All three operators are based on this method.

2.2.1. Roberts operator. Roberts used the Roberts crossover algorithm. The idea behind the Roberts crossover algorithm, as it's called, is to find the horizontal and vertical edges of the target, put them together to produce edge detection, and then use two filters to skew the edges of the defined image.

The convolution operator of Roberts operator is:

\[
\begin{bmatrix}
1 & 0 \\
0 & -1
\end{bmatrix}
\begin{bmatrix}
0 & -1 \\
1 & 0
\end{bmatrix}
\]

2.2.2. Sobel operator. Sobel crossover difference operator, because of its small template and relatively small calculation, can obtain the image details of contour. However, because the template size is even, the pixels to be processed cannot be placed in the center of the template, or a half-pixel fault may occur as a result. Sobel difference operator is an odd-dimensional directional difference operator template.

The convolution operator is:

\[
\begin{bmatrix}
-1 & -2 & -1 \\
0 & 0 & 0 \\
1 & 2 & 1
\end{bmatrix}
\begin{bmatrix}
-1 & 0 & 1 \\
-2 & 0 & 2 \\
-1 & 0 & 1
\end{bmatrix}
\]

2.2.3. Prewitt operator. The Prewitt operator is very similar to Sobel operator. 3x3 total convolution template is used to detect gradients in the X direction and Y direction. It uses the method that the gray difference between the upper pixel and the lower pixel, the left pixel and the right pixel reaches the maximum at the edge to detect the target edge.

The convolution operator is:

\[
\begin{bmatrix}
-1 & 0 & 1 \\
-1 & -1 & -1 \\
-1 & 0 & 1
\end{bmatrix}
\begin{bmatrix}
-1 & -1 & -1 \\
0 & 0 & 0 \\
1 & 1 & 1
\end{bmatrix}
\]

2.2.4. Canny operator. The basic idea any operator is to first use the gaussian function to smooth the image. Then, the maximum value of the first derivative and the minimum value of the first derivative correspond to the strong point of gray scale change and the weak point of gray scale change, that is, the edge of the image, and at this point the second derivative is zero. Therefore, these two thresholds are used to detect strong and weak edges. Canny operator can detect most edges, and the fact that it is not easily disturbed by noise makes it possible to detect real weak edges.
3. Experiments

Figure 1. The infrared picture of the fault insulator.

Figure 2. The grayscale picture of the fault insulator.

The grayscale picture is showed in figure 2.

This section carries on the experiment to the above algorithms and compares the results of the proposed algorithms. The infrared picture of the fault insulator is showed in figure 1.

3.1. Threshold Segmentation

As showed in figure 3, it can be found that there are three peaks and two troughs in the grey histogram. According to the principle of histogram threshold method, we set two troughs as the threshold values. The thresholds are 30 in figure 4 and 150 in figure 5, respectively. Compared with the original image, it can be found that figure 5 is very effective in highlighting the target we focus on, and the infrared image is effectively segmented. However, figure 4 due to the threshold setting problem, the entire right side of the graph is misjudged as the target. Therefore, it can be found that the disadvantage of histogram threshold segmentation lies in the presence of multiple peaks and troughs, and the threshold setting will be wrong. Through this point, we can realize that the threshold setting is the key of the whole threshold segmentation algorithm.

Figure 3. The gray histogram.

Figure 4. Histogram threshold segmentation (threshold is 30).
Figure 5. Histogram threshold segmentation (threshold is 150).

3.2. Edge Segmentation

Figure 6. Canny edge.

Figure 7. Roberts edge.

Figure 8. Sobel edge.

Figure 9. Prewitt edge.

The experiment result of Canny edge is showed in figure 6. The experiment result of Roberts edge is showed in figure 7. The experiment result of Sobel edge is showed in figure 8. The experiment result of Prewitt edge is showed in figure 9. From the simulation experiment results, it showed that Canny operator detected a visually obvious background boundary, and other operators did not detect it, which shows that Canny operator is very sensitive to the changes in gray scale, more conducive to detecting the edge of the image. Canny operator is used to detect the image edge is very smooth, and. The edge
extracted by Roberts operator is rough, which indicates that its anti-noise performance is not very ideal. Compared with Sobel operator and Prewitt operator, its anti-noise performance is the worst. Both Sobel operator and Prewitt operator can propose edges well and have good anti-noise performance. However, due to the disadvantages of high resource occupancy rate and poor real-time performance brought by Prewitt operator algorithm itself, Sobel operator can only detect horizontal and vertical edges and is not suitable for complex edge targets. Based on the above analysis and experimental results, Canny operator is a good choice for edge detection.

4. Conclusion
This paper adopts the method of analyzing and processing power equipment infrared image to identify and locate the fault of power equipment. This paper mainly discusses two commonly used image segmentation algorithms: threshold segmentation and edge segmentation. In the threshold segmentation, we discuss and compare the histogram threshold method and automatic threshold method. In the edge detection, we discuss four common edge detection operators: Roberts operator, Sobel operator, Prewitt operator and Canny operator. Compared with the experimental results, the conclusion is drawn that Canny operator edge detection, as an optimal algorithm, the extracted edge is very smooth and the anti-noise performance is also very ideal.

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