The Automatic Identification Method of Switch State

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***Abstract* - With the development of modern power system, more and more high complexity of the substation, there are more and more switches to need to control the line of a substation, but also need to keep track of the state of the switch. Taking into account the substation monitoring system, we only need to understand the state of knife gate is open or closed. This paper puts forward the improved Hough transform method, first of all the image were edge detection, and then using Hough transform for line detection to identify the knife switch, The method is simple and is less space and noise in straight line , the use of this method to identify the state of the knife, the significantly improved state estimation accuracy, the normal operation of power system analysis software in real time and improve the accuracy of analysis results laid a good foundation, significantly improve the accuracy of state estimation, lay a good foundation of the normal operation of power system analysis software in real time and improve the accuracy of analysis results .**

Keyword - Switch state; Color space; Hough transform; Edge detection

I. INTRODUCTION

In the extra high voltage open outdoor substation, the electrical equipment transform from one to another state or change the operation mode, needing to carry out a series of electrical equipment switching operation. With the pilot construction of intelligent substation, switch operation has been improved to a remote automatic operation mode, but still need to the workers involved in every operation by doing the scene confirmed circuit breaker, disconnecting switch position is in place, the operation is complete and accurate[1-2]. Although this model reduces the labor intensity of operating personnel, shorten the operation time, but relies on the subjective judgment of the field personnel by large field staff knowledge and experience and other constraints, is prone to false positives. In view of the above phenomenon in this paper a practical switch state identification method is proposed, the switch state error corrected, greatly reduce the labor intensity of operating personnel, shorten the operation time, and eliminate the influence of subjective factors of field personnel.

II. THE PRINCIPLE OF HOUGH TRANSFORMS

The Hough transform is a simple and effective method used to extract the edge features, which can extract straight line, circle, ellipse, curve two even arbitrary shape edge[3].The basic idea is to transform the original image into the parameter space, with most of the boundary points of some parameters to describe the image line, obtain corresponding to the peak value of the required information by setting the accumulator. Hough transform is not sensitive to local defects, robustness to random noise and suitable for parallel processing and other excellent properties, highly favoured by image processing, pattern recognition and computer vision scholars[4-5]. The outstanding advantage of Hough transforms is to convert relatively difficult global detection problem for local peaks in the parameter space to relatively easy to solve the detection problem.

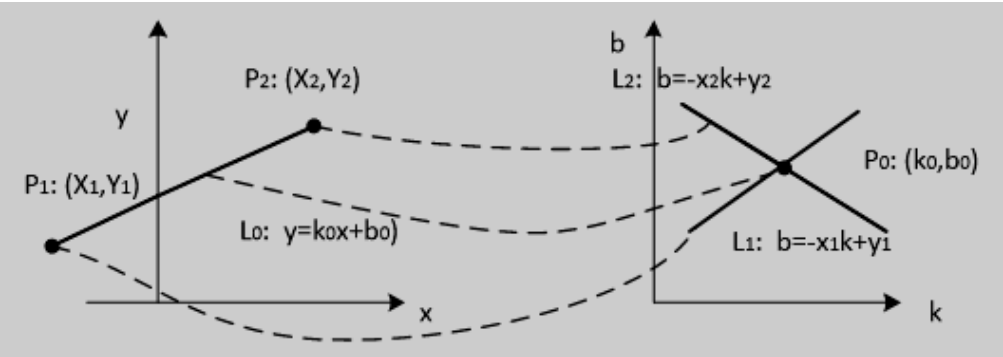

Fig. 1. Hough transforms

The principle is shown in Figure1, the linear L in plane rectangular coordinate system is expressed as:

$$y = kx + b \tag{1}$$

Among them, K is slope, B is intercept, the different points (x, y) on Line L in the parameter space is transformed into linear intersects at a point P. Obviously, if we can determine P points (local maximum) in the parameter space, so achieve a straight line testing. Any line in the plane can also be used to represent the polar coordinate equation, which can be determined by two parameters α and ρ, for any point on the image in space, its function is:

$$\rho = x\cos\alpha + y\sin \tag{2}$$

is the distance between the starting point to line, α determine the direction of the line, is the angle between the vertical line that the origin to the line and the X axis direction. If the n points in the same line on the L are transformed, the n points of original image space are corresponding to n sine curves in the parameter space, and these curves intersect at the same point.

III. IMAGE PREPROCESSING

A. Remove the Interference Of Reflecting Light

Histogram equalization is performed on the RGB image, eliminating the influence of reflective to switch position. Histogram stretching is adjusting the histogram by contrast stretching to "expand" the difference between foreground and background gray, in order to enhance the contrast. This method can use the linear or nonlinear method to achieve histogram equalization, by using the cumulative function of the gray value of the "adjustment" to achieve the contrast enhancement [6-7].

The gray level of the point (x, y) in the original image is f, and in the changed image is g, and then the image enhancement method can be expressed as the gray f at A is mapped to g. The mapping function in the gray level histogram equalization can be defined as:

$$g = EQ(f) \tag{3}$$

This mapping function EQ (f) must meet two conditions, L is the gray series, EQ (f) is a single value increasing function when f ranges from 0 to L-1. This is to ensure the enhancement do not disturb the original image gray sequence, the transformed original grey level remain the arrangement from black to white. This condition ensures the consistency of the dynamic range of gray values before and after the transformation when f and g range from 0 to L-1.

B. Color Space Conversion

According to the recognition of the color of the H, S threshold to determine the scope of the recognition of color, RGB color space is converted to HSV color space. Set (R, G, b) is coordinates of the red, green and blue color, their value is the real number between 0 to 1. Set max is equal to the largest among r, g and b, min is equal to the value of the minimum, h value is standard to located between 0 to 360 degrees, And the h is not defined when h=0 for max = min (which is gray), calculated as:

$$h = \begin{cases} 0^\circ, & if\ max = min \\ 60^\circ \times \frac{g-b}{max-min} + 0^\circ, & if\ max = r\ and\ g \geq b \\ 60^\circ \times \frac{g-b}{max-min} + 360^\circ, & if\ max = r\ and\ g < b \\ 60^\circ \times \frac{g-b}{max-min} + 120^\circ, & if\ max = g \\ 60^\circ \times \frac{g-b}{max-min} + 240^\circ, & if\ max = b \end{cases} \tag{4}$$

$$s = \begin{cases} 0, & if\ max = 0 \\ \frac{max-min}{max} = 1 - \frac{min}{max}, & others \end{cases} \tag{5}$$

$$v = \max \tag{6}$$

C. Binarization

Divide the overall image according to the color recognition of H, s threshold. The pixel values in the H, S within the range is set to 255 pixels, not in its internal set to 0. In this way, we get the two value image of the knife gate. In the image, the white area is the knife gate region, and the black is an independent region. Due to the knife gate monitoring is carried out in the outdoor situation, so we need to take into account the wind, rain, fog and other adverse environmental impact [8]. The wind will cause the camera jitter, images will be blurred, and in this case Hof transform is possible error, so need a locally adaptive binarization for image binarization. The identification color may become not clear in rain and fog weather, and it is possible to identify color as background based on the color threshold segmentation in HSV color space, resulting in a loss of information. The color gray image stretching algorithm can strengthen image contrast, and make image recognition discoloration more clearly, and then use the Gaussian filter for removing white noise and color threshold segmentation to get the binary image. Because of the salt and pepper noise after binarization, we can use median filter to smooth the image, and get a smooth binary image [9-10].

D. Edge Detection

If we carry out Hough transform to the whole image ,it will slow down the speed, so in order to improve the computing speed Hough transform, it also need to use the image edge detection. The edge points or feature points are extracted from the image plane, and the Hough transform is performed on these feature points. In this paper, using Canny operator for image edge detection, object edge detection, first roughly detect the contour points, then the original detected contour points are connected together, simultaneous detection, missing boundary points of connection and remove the false boundary points.

IV. KNIFE GATE IDENTIFICATION

The traditional Hough transform discrete the transform domain to count the number of aggregation points in sub-regions, while the discretization will lead to statistical error [11-13].

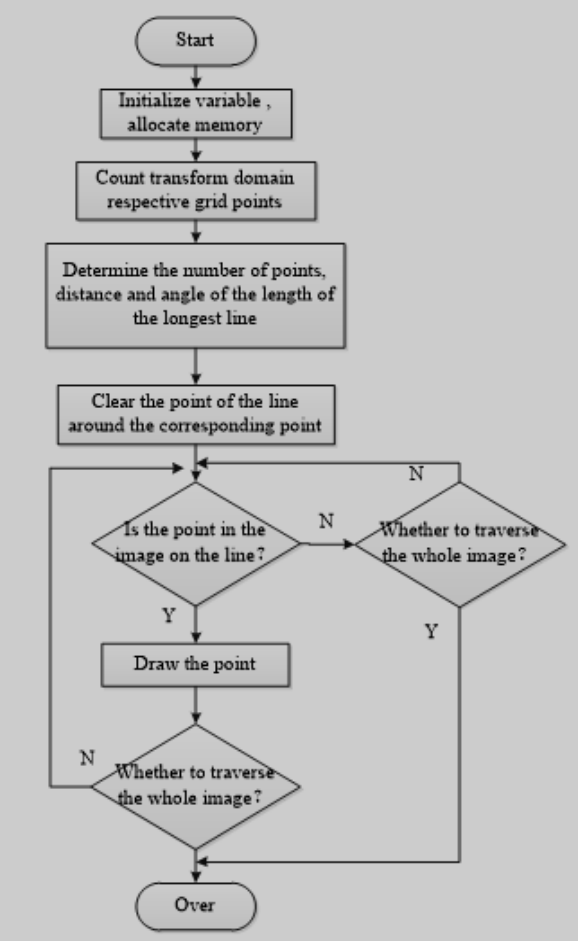

Fig.(2). The process of improved Hough transforms

In this paper, the algorithm of line detection is from long to short, the longest straight is drawn after detected, the corresponding points of the longest straight line in the transform domain on is removed, so as to eliminate the interference of the next line to be detected and this cycle until the last line is detected. In this way, the transform domain is discrete, but the point in the transform domain is removed due to the deletion of the points on the front line which has been detected, and the statistical error caused by the discretization is eliminated. The flow chart of improved Hough transformation is shown in Figure 2.

The three knifes with a straight appear in the two value image side by side, if the two value images is transformed in Hof transform to detect straight lines, you can know the first coordinates of each switch.

If there is no straight line to exist within the isolation switch region, it is assumed that the isolating switch is divided into state, labeled 0, while there is a straight line to exist, calculate the angle between the detected linear and rectangle vertical edge in the image to be matched, If the angle between the line and the isolated switch area is less than a certain threshold value, the isolation switch is considered as "closed" state, and mark 1. Recognition process result is shown below:

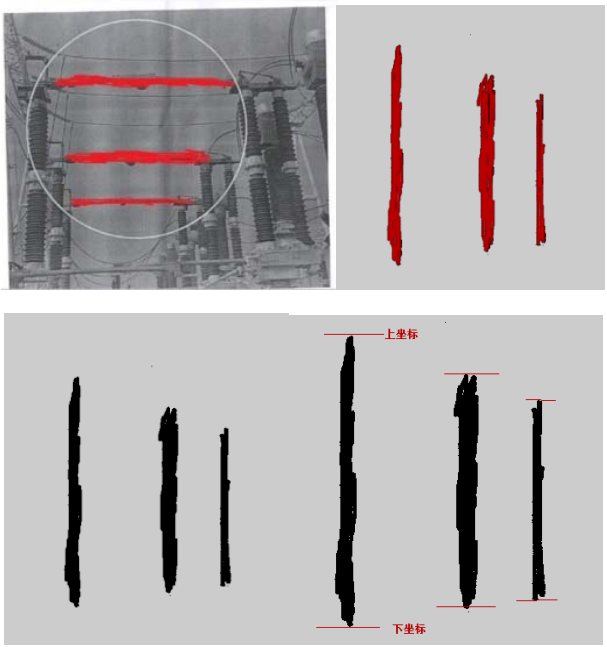

Fig.(3). Knife gate status identification chart

We have selected a number of switching gates in the substation to identify, and the results as shown in the figure 4, manual observation shows that only two errors, the accuracy rate reach 92%.

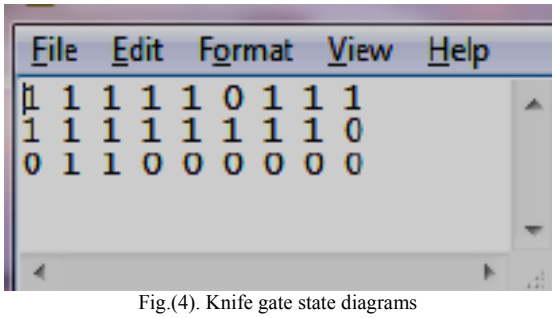

Fig.(4). Knife gate state diagrams

V. CONCLUSION

Taking into account the substation monitoring system, we only need to know the knife gate state that is disconnected or closed, and this paper put forward the method of improved Hough transform. The algorithm proposed in this paper can eliminate the statistical error caused by the discretization of the transform domain, thus eliminating the effect of long line detection on short line detection, which can be detected at the same time. The method can automatically identify and correct the error of the state of the knife gate, and give the alarm information to the suspicious state of the switch.

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