Research and Application for Intelligent Video Analysis Algorithm in Substation Monitoring System

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ABSTRACT: This paper is mainly based on the video monitoring of unmanned substation, with the detection and tracking object of moving target, combined with the inter-frame difference method and background difference method, in order to achieve effective detection of moving targets through improving the traditional algorithm; combined with cam-shift algorithm and mean-shift algorithm to reduce the calculated amount and improve the accuracy of target tracking, in order to achieve intelligence level of substation video monitoring. This paper uses the computer vision and video analysis method to further analyze and understand the image sequences recorded by the camera, and links with related equipment to do simple processing while timely giving an alarm and feedback to monitoring personnel. In this way, the monitoring personnel can offer centralized processing for accident alarm, thus greatly reducing erroneous judgment and missing judgment of accidents, and improving the reliability, accuracy and timeliness of the alarm. Therefore, the intelligent video analysis is applied to substation attending, and combined with the traditional monitoring system, thus having a very important significance on security monitoring of the substation.

Keywords: video monitoring; moving target detection; moving target tracking

1 INTRODUCTION

With the development of power grid technology, more and more domestic substations tend to achieve unmanned substations. Currently, unmanned substations mainly use the camera to transmit all the video data to the monitoring center for monitoring and analysis by the monitoring personnel, and cooperate with sensors and other facilities for emergency alarm. However, among a large number of video information generated from long-time monitoring, useless information occupies a major part, while key information only accounts for less than 1%. According to data statistics, when the monitoring personnel focus on the monitoring screen for more than a certain duration, their attention will be greatly reduced.

In case of invasion of foreign matters and other special circumstances in the substation, the monitoring personnel are most likely to miss important information and thus produce serious consequences. The use of substation intelligent video analysis and warning system researched and developed by the project reduces unnecessary manpower consumption and waste of channel resources, and greatly improves the timeliness and accuracy of video processing.

This paper mainly researches the application for intelligent video analysis technology in substation, and presents an improved target detection algorithm and tracking algorithm for the shortcomings of part of algorithm during processing.

2 APPLICATION STATUS OF INTELLIGENT VIDEO ANALYSIS TECHNOLOGY IN SUBSTATION

Foreign intelligent video analysis technology is mostly used in the field of security, and the vast majority of algorithms and techniques are in hands of American and Israel companies. Many domestic merchants and scientific research institutions make efforts to develop and research independent technology while introducing foreign advanced technology. However, the intelligent video monitoring technology is not widely used in the substation, especially in the domestic substations. Main reasons are as follows:

The first is relatively high cost. The intelligent video technology formally enters into the domestic mar-
The algorithm is based on the adjacent frame difference method, and uses the median filtering method to establish background images, and detect a complete moving target, and combines with the detection results of adjacent frame difference method to compensate for the detection error caused by the sensitivity of background difference method to environmental factors. The specific steps are as follows:

1. First, to obtain the current frame to be processed and previous frame of the image, carry out gray processing, and record the images obtained as $f_k(x, y)$ and $f_{k-1}(x, y)$, which respectively represent the video images at the time of k and k-1, and the amplitude ($f$) corresponding to any point $i(x, y)$ is the gray value at the corresponding points.

2. To process the video images obtained according to the following adjacent frame difference method, thus obtaining difference images $D_k(x, y)$

$$D_k(x, y) = |f_k(x, y) - f_{k-1}(x, y)|$$

To select the appropriate threshold values for binarization processing of the difference image $D_k(x, y)$, thus obtaining a binary image $R_k(x, y)$.

3. To provide median filtering processing for R, G and B channels of video sequence selected, and finally generate a moving background image $f_b(x, y)$.

4. To use the current frame image $f_k(x, y)$ and background image $f_b(x, y)$ for difference, thus obtaining a moving target image $R_k(x, y)$.

5. To do OR operation for $R_k(x, y)$ and $R_b(x, y)$, and to fill up the detection results of inter-frame difference method by the use of target area obtained by background modeling, thus obtaining a complete moving target.

6. To provide mathematical morphology filtering processing for the images obtained, and subsequent processing of the connectivity analysis, and determine the moving target according to the area of connected area greater than the decision threshold.

3.2 Improved moving target tracking algorithm

Commonly used tracking algorithms include cam-shift algorithm and mean-shift algorithm. The cam-shift algorithm uses the color features in the image for target tracking, and its tracking effect is better than that of mean-shift algorithm. However, there is a need to seek for target area in each frame image while tracking target by the use of cam-shift algorithm, and then make color probability statistics, so that the calculated amount of tracking algorithm is too large, with a certain impact on the timeliness of tracking results. This paper combines with Kalman filtering algorithm and cam-shift algorithm for tracking moving target, and hopes to reduce the calculated amount of tracking, and improve the timeliness and accuracy of target tracking.

This paper first uses Kalman filtering to predict the potential position of target in the next image, and then searches target in the vicinity of the predicted position to obtain color features. The improved method aims at reducing the search area, and increasing the accuracy of target tracking while improving tracking speed. The
implementation process of algorithm is as follows:

1. To use the target detection technology to detect moving area, and obtain color information of moving target in the area;
2. To use Kalman filter to predict the position of moving target in the next image, and construct a matching template in the vicinity of this position;
3. To search the tracking target in the matching template according to the cam-shift algorithm, and achieve target tracking.
4. To update the moving target template and parameters of Kalman filter after completion of target tracking, and return to (2). The algorithm iterations finish until the last frame of video.

Algorithm flow chart is shown in Figure 1:

![Algorithm flow chart](image)

4 APPLICATION FOR INTELLIGENT VIDEO ANALYSIS TECHNOLOGY IN SUBSTATION VIDEO MONITORING

Except for invasion of foreign matters, remnants, detection moving and other conditions in general sense of security system, for the objects processed and analyzed by the intelligent video analysis technology of the substation, this paper mainly detects and tracks the moving target. Through application for the improved algorithm, the test results are as follows:

1. Experimental results and analysis of improved algorithm of moving target detection

In order to verify the effectiveness of the moving target detection method proposed in this paper, now, matlab image processing module is used for testing the selected sample video. In order to compare with the effect of this algorithm and adjacent frame difference method and three-frame difference algorithm, these two algorithms are increased with detection steps of the morphological filter, binarization and connected region that are the same with the improved algorithms. Next is the effect diagram of these two algorithms while processing the same frame image.

In the experimental results, the sample video 3 with a relatively large difference between the moving target gray and the background image gray is first selected for algorithm testing, and the test results fully prove the effectiveness of the algorithm. Then, the sample video 1 with similar moving target gray and background image gray in the substation is tested, and the detection results prove a good effect of improved algorithm in this case.

![Effect diagram of personnel detection processing with adjacent frame difference method](image)

![Effect diagram of personnel detection processing with three-frame difference method](image)

![Effect diagram of personnel detection processing with improved algorithm](image)

![Effect diagram of substation personnel detection processing with improved algorithm](image)

Figure 3 and Figure 4 derive from human walking video under a fixed outdoor background. Through comparison, we can see that three-frame difference method and adjacent frame difference method can
only roughly detect the contour of moving target, and the contour of detection results of three-frame difference method is slightly larger than the contour of moving target in the image, indicating a false contour in the detection process. The improved detection algorithm can completely detect the movement and shape of moving characters, especially in the upper part of moving target with substantially constant shape and contour, while the detection effect of lower limbs is slightly inferior.

Figure 5 is a part of effect diagram for processing sample video 1 by the use of improved target detection algorithm. This paper selects three-frame images in 147-frame processing results to reflect the detection effect of algorithm. The original video image shows that, part of clothes of characters is similar to the ground color and gray in the background, but the detection result still completely shows the information of moving target, indicating that the improved target detection algorithm can effectively solve the deficiency when there is a “vacancy” of frame difference method in moving target detection due to similarity of the moving target and background gray. Combined with Figure 4 and Figure 5, it shows that the improved algorithm has strong adaption to moving process with the frame difference method, and it is prone to implement. Meanwhile, combined with the advantages of background difference method, it completely detects the moving target and ensures the accuracy of test results.

(2) Analysis of experimental results of improved moving target tracking algorithm
The target tracking algorithm proposed in this paper is used for processing the sample video 1, and three frames are selected from 147-frame images to select the tracking effect. The processing results are shown in Figure 6. Figures 7 gives out the comparison of the target tracking effect by separate use of cam-shift target algorithm. Table 1 gives out the comparison of centroid coordinates of moving targets tracked by cam-shift algorithm and algorithm proposed in this paper.

![Figure 6](image1)  
(a) Original image of 50-th frame  (b) Original image of 90-th frame  (c) Original image of 110-th frame  
(a) Tracking image of 50-th frame  (b) Tracking image of 90-th frame  (c) Tracking image of 110-th frame  

Figure 6. Effect diagram of cam-shift algorithm tracking test.

![Figure 7](image2)  
(a) Tracking image of 50-th frame  (b) Tracking image of 90-th frame  (c) Tracking image of 110-th frame  

Figure 7. Effect diagram of tracking algorithm test of this paper.
The introduction of intelligent video analysis technology are increasingly prominent.

monitoring, and also one of current hot issues in the key technology of realization of intelligent video intelligence. Moving target detection and tracking is an inevitable trend of substation monitoring.

The diagram of experimental results shows that the algorithm can effectively track the moving target.

5 CONCLUSION

With the promotion of unmanned substations, the traditional video monitoring system is unable to meet the requirements of unmanned substation, and in the field of computer vision, the advantages of intelligent video analysis technology are increasingly prominent. The introduction of intelligent video analysis technology is an inevitable trend of substation monitoring intelligence. Moving target detection and tracking is the key technology of realization of intelligent video monitoring, and also one of current hot issues in the domestic and international image processing field.

This paper analyzes and processes the images with moving target, and the detection results prove that, compared with the traditional adjacent frame difference method and three-frame difference method, the improved algorithm can completely detect moving targets, and effectively avoid the generation of false contour, thus further improving the detection accuracy of moving targets; in terms of target tracking algorithm, this paper combines with cam-shift algorithm and Kalman filter algorithm to achieve moving target tracking. The images of tracking results show that, the tracking algorithm proposed in this paper reduces the calculated amount and improves the accuracy of target tracking, and effectively tracks moving targets, and greatly improves the intelligence level of unmanned substation.

As can be seen from Figure 7 and Table 1, the region of tracking results obtained by cam-shift algorithm is larger than that of the results of improved tracking algorithm proposed in this paper, and has a slight hysteresis phenomenon. This paper presents an improved tracking algorithm and uses Kalman filter to predict the movement of target, and search moving target in the vicinity of predicted points, thus improving the accuracy of target tracking while reducing the calculated amount. The diagram of experimental results shows that the algorithm can effectively track the moving target.

Table 1. Comparison with tracking centroid of cam-shift algorithm and algorithm in this paper.

<table>
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<tr>
<th>Image frame number</th>
<th>Actual centroid</th>
<th>Centroid of cam-shift tracking algorithm</th>
<th>Centroid of tracking algorithm in this paper</th>
<th>Error of cam-shift algorithm error</th>
<th>Error of algorithm in this paper</th>
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<tbody>
<tr>
<td>50</td>
<td>(284.0, 82.7)</td>
<td>(280.2, 80.0)</td>
<td>(284.0, 80.0)</td>
<td>(3.8, 2.7)</td>
<td>(0, 2.7)</td>
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<tr>
<td>60</td>
<td>(265.8, 88.7)</td>
<td>(259.4, 85.6)</td>
<td>(260.9, 88.4)</td>
<td>(6.6, 3.1)</td>
<td>(0.9, 0.3)</td>
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<tr>
<td>70</td>
<td>(244.7, 87.1)</td>
<td>(242.8, 82.5)</td>
<td>(245.1, 83.9)</td>
<td>(1.9, 4.6)</td>
<td>(0, 3.2)</td>
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<tr>
<td>80</td>
<td>(223.3, 90.3)</td>
<td>(215.9, 91.2)</td>
<td>(222.8, 88.4)</td>
<td>(7.4, 0.9)</td>
<td>(0.5, 1.9)</td>
</tr>
<tr>
<td>90</td>
<td>(209.5, 89.7)</td>
<td>(204.3, 83.8)</td>
<td>(209.8, 85.2)</td>
<td>(5.2, 5.9)</td>
<td>(0.3, 4.5)</td>
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<tr>
<td>100</td>
<td>(212.9, 97.3)</td>
<td>(203.6, 93.4)</td>
<td>(209.7, 94.7)</td>
<td>(9.3, 3.9)</td>
<td>(3.2, 2.6)</td>
</tr>
<tr>
<td>110</td>
<td>(174.7, 94.4)</td>
<td>(166.2, 92.5)</td>
<td>(171.9, 92.1)</td>
<td>(8.5, 1.9)</td>
<td>(2.8, 2.3)</td>
</tr>
</tbody>
</table>

REFERENCES


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