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Research on Smart Safety Electronic Fence Technology Based on Image Processing

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Research on Smart Safety Electronic Fence Technology Based on Image Processing

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Abstract. With the development of scale of the power grid, the phenomenon that the construction personnel across the safety fence at will occurs frequently, which brings great hidden trouble to the safety production. In allusion to the existing problem of the safety fence without monitoring and alarm function, in which the principle of inter-frame difference method is used to screen out the illegal workers, making accurate diagnosis of the illegal behavior, and sending warning information to remind the illegal workers by using the method of trajectory tracking of moving object to filter out the random disturbance signal, so as to ensure the safety of the construction.
Keywords. Smart Safety Electronic Fence; Inter-frame Difference Method; Target Tracking Technology

1. Introduction

As one of the important safety tools to protect the safety of workers in the construction process of power grid, safety fence realizes the isolation between the construction site and the surrounding environment to keep non-workers and workers away from dangerous areas and ensure the safety of personnel. However, the current widely used safety fence has the following problems:

(1) The existing fence is too low in height and easy to be crossed on site.
(2) The existing fence does not have the monitoring function, which can not be used to monitor the illegal workers.
(3) The existing fence has no warning function, which can not send alarm message to the illegal workers had been found.

All this problems leads to the phenomenon that the construction personnel and non-construction personnel cross the safety fence without authorization in the construction process frequently, which brings great potential safety hazards to the safe construction and directly threatens the life safety of people in serious cases. In order to promote the construction and improvement of the safety of electric power construction site, putting forward higher requirements for the safety production and management of electric power, the active design and improvement of power construction site operation intelligent monitoring system has become an urgent need to improve the power construction site management level and ensure the safety of personnel.

Through the investigation of the construction site, combined with the current image processing technology, this paper puts forward the smart safety electronic fence technology based on image processing. This system uses the principle of inter-frame difference method to screen out the illegal workers, making accurate diagnosis of the illegal behavior, and sending warning information to remind the illegal workers by using the method of trajectory tracking of moving object to filter out the random disturbance signal, so as to ensure the safety of the construction.

2. System framework design

In order to implement the design of smart electronic fence system based on image processing technology, considering the actual requirements of substation site, the framework of the whole system is designed based on the analysis of the principle of inter-frame difference method, which is shown in Figure 1.

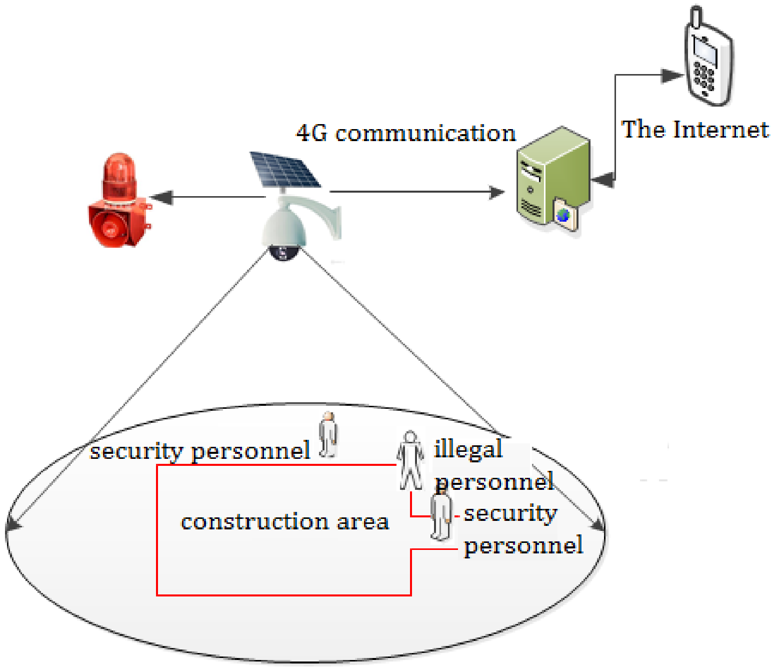

Figure 1. Frame Diagram of the Smart Electronic Fence System

The whole system is mainly composed of front-end camera monitoring equipment, transmission network and platform server. The front-end equipment is an intelligent video monitoring device, which can implement real-time collection and storage of live videos or pictures. Firstly, the system designs the monitoring area (the red areas as shown in Figure 1) through the monitoring software. Then, the system uses the principle of inter-frame difference method to monitor whether objects appear in the monitoring area, analyzing the movement of moving objects by using the method of trajectory tracking trajectory. When the track of the monitoring and safety area crossing shows that some construction personnel cross the safety fence, the system will send out warning messages to those who violate the safety electronic fence through alarm to ensure the safety of construction. In addition, the system adopts solar power supply to implement the independent power supply technology and maintain the normal operation of the equipment without considering the problem of power supply, which improves the applicability of the system on site. At the same time, the front-end equipment uses 4G to transmit the front-end data to the transmission management platform, enabling the operators to view real-time monitoring, videos and pictures remotely, which shows the status of the construction area in detail, and provided a basis for the construction standardization evaluation of the future construction team.

3. Target Tracking Technology

In order to identify the phenomenon of personnel illegally acrossing the security electronic fence in In the process of electric power construction, the GMMs [1] background subtraction is used to detect foreground objects in the system, and the objects track is implemented by a combination of algorithms. In the process of trajectory tracking, in order to largely lower the influence on multiple target tracking by possible inaccurate background subtraction, the state estimates of tracking are predicted by Kalman filters, and they are associated with observation data from the background subtraction by an MHT.

In order to perform reliable target tracking, it is necessary to detect and model moving foreground objects. The state of objects is modeled as x in tracking by the Multiple Hypothesis Tracking (MHT) method. Position is the primary attribute of objects in dynamic scenes, which is also the most common used feature in tracking [2, 4]. and a color distribution representation is also a useful and important feature in modeling foreground objects[3, 4, 5]. By analyzing the advantages and disadvantages of these two tracking methods, our idea is to embed two-dimensional spatial information into color space to Realize objects tracking reliability.

The MHT method based on Kalman filtering is then used for multiple target tracking. In an MHT approach, the detected foreground objects are very important to the accuracy of tracking results. Un-fortunately, there are often foreground object errors after GMMs background subtraction. These errors fall into four situations: (1) missing detection of a foreground object and (2) large noise blobs. To overcome these problems, our tracks, which are preliminary, are used as feedback for better object detection and eventually tracking correction.

First, a missing detection method is shown in Figure 3 by using color histograms matching. Then we represent each abnormal tracking blob as a mixture of color distributions by using a multi-part RGB color histograms representation. Tracked objects are saved as rectangular blobs in our system, so seven possible divisions of the rectangles are shown in Figure 2. The first histogram is for the whole region of the foreground object blob, and the second to the fifth histograms are respectively calculated based on the four equally divided parts of the whole. The last two ones are from the inside and Figure 2. Multi-part color representation in seven divisions. a) whole, b) rotation sensitive division, c) size sensitive division, d) target overall division the outside half of the foreground object blob. The tracking output regions from the last frame are set as templates, to which the blobs at the predicted position of current frame are matched, if no observations is assigned to those existing tracks like issue (1) or if we need to get rid of noise interferences like issue (2).

$$d_i = \sqrt{1 - \sum_{j=1}^{3} \sqrt{h_{i,t} \times h_{i,t-1}}} \tag{1}$$

$$D = \frac{\sum_{i=1}^{N} d_i}{N} \tag{2}$$

$h_{i,t-1}$ denotes the ith histogram of the template, and $h_{i,t}$ denotes the ith histogram of the candidate. Here N is 7 because of seven divisions of the blob. The “3” in equation 4 is to sum over the three-dimensional RGB space.

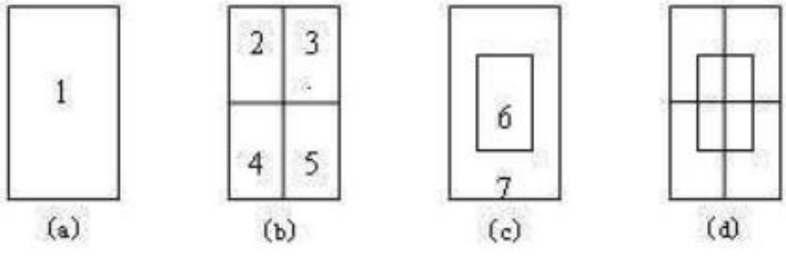

Figure 2. Color representation in seven divisions.
a)whole, b)rotation sensitive division, c) size sensitive division, d) target overall division

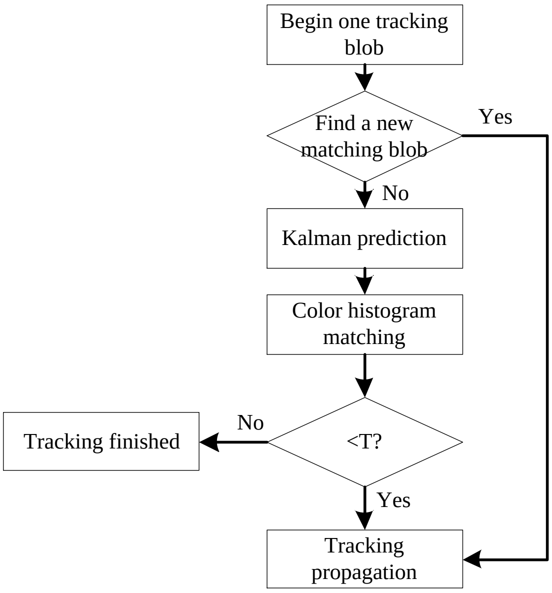

Figure 3. Color representation for missing detection

4. The Design of System Diagnostic Method

In order to enable the system to monitor the violation of the safety fence, this paper analyzes the process of people crossing the fence in violation of regulations. The analysis results show that: 1) when a person break the rule of the safety fence, there is an overlap between the person and the electronic fence, causing obstruction of the electronic safety fence; 2) When a person enters the construction area from the entrance, the camera angle may also cause people to block the electronic fence; 3) Through the analysis of the trajectory of the movement of the person (as shown in Figure 4), when the person illegally crossing the safety electronic fence, the movement trajectory and the electronic fence will be intersected, when the person enters correctly from the entrance, although the image has a occlusion safety electronic fence Phenomenon, but its trajectory does not intersect with a secure electronic fence. It can be seen that the method of intersecting the trajectory with the safety electronic fence can eliminate the misjudgment caused by the above-mentioned personnel to block the safety electronic fence caused by the safety electronic fence, and realize the accurate judgment of whether the personnel violates the safety electronic fence. It can be seen that the method of judging whether the trajectory intersects with the safety electronic fence can eliminate the misjudgment of the violation of the safety electronic fence caused by the above-mentioned personnel blocking the safety electronic fence, and realize the accurate judgment of whether the personnel violates the safety electronic fence. Therefore, this thesis proposes a method based on the combination of image overlap and moving trajectory to realize the diagnosis of the violation of the safety electronic fence.

To achieve the diagnosis of the electronic fence based on the image processing, the system is designed and written based on the hardware resources of the system. The flow of the whole program is shown in Figure 5. The workflow of the entire system is listed as follows: Firstly, during the construction process, the measured scene is constantly changing, in order to avoid the misjudgment caused by the change of background image, the system periodically samples and replaces the measured scene when it is confirmed that no personnel violates the safety electronic fence. Then collect the image in real time, and process the intensity and shadow of the image, and calculate the difference between the specified area and the background image by comparison with the background image. When the difference area is larger than the set value (greater than 2000 pixels), it is considered that there are people around the electronic fence. The third step, the displacement of the difference area is analyzed. When the movement track of the person intersects with the safety electronic fence, it is considered that there is a violation phenomenon of the electronic fence, the system issues an alarm message, and at the same time, the offending personnel are photographed and uploaded. At the same time, the system measures the wearing state of the helmet in the designated electronic fence area. Once a person without a helmet is found, the system issues an alarm message and simultaneously shoots and uploads the offending person.

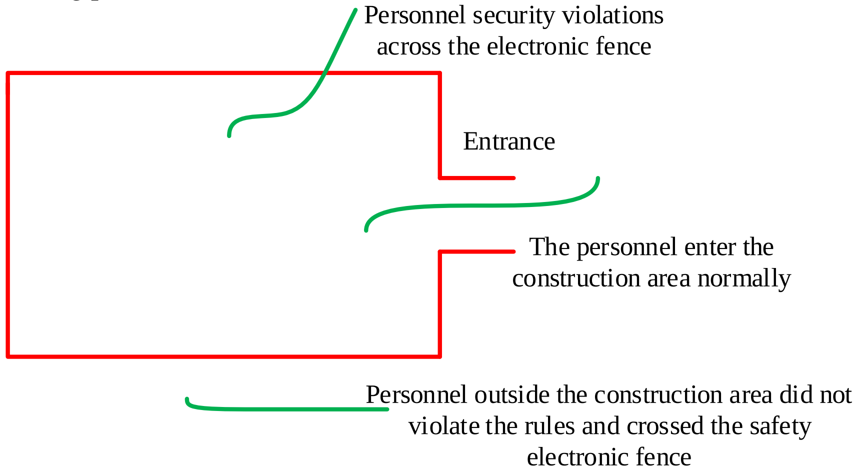

Figure 4. Various trajectories of personnel in the secure electronic fence

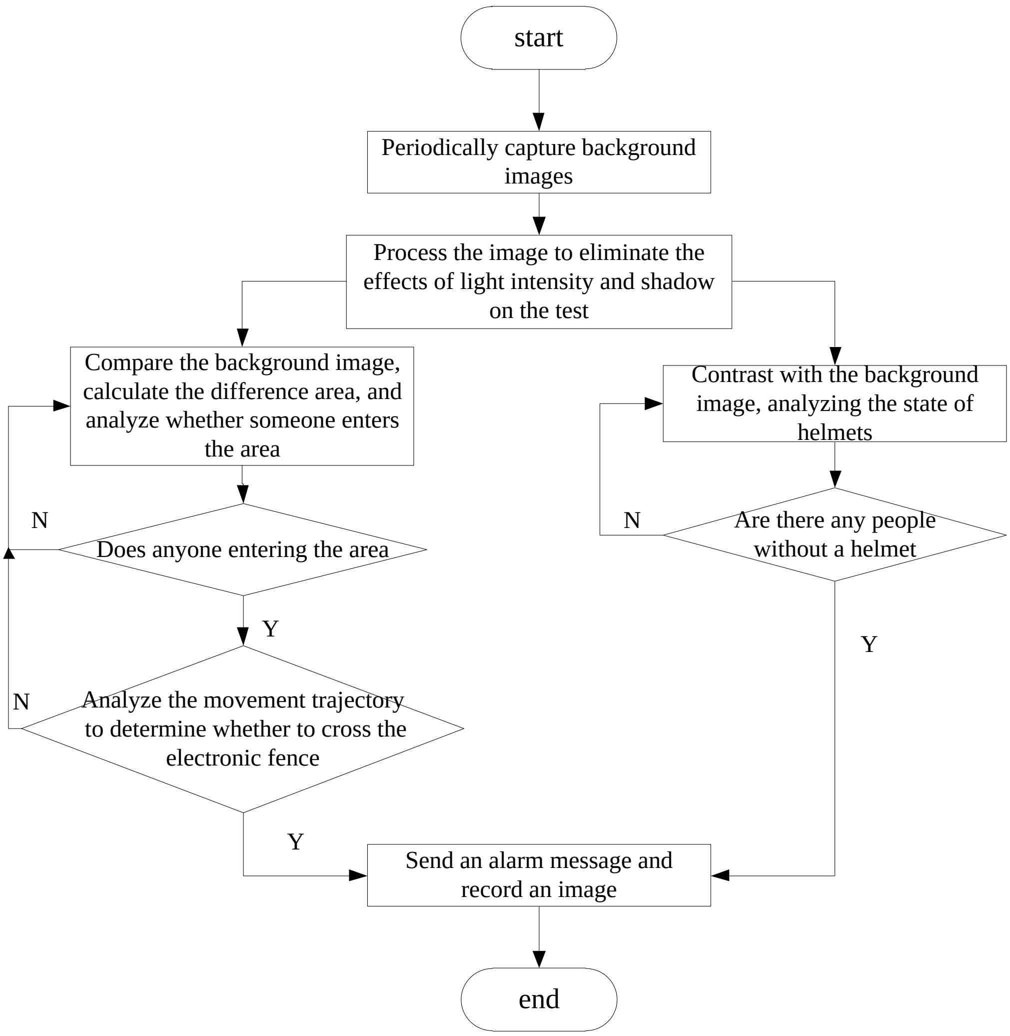

Figure 5. Flow chart of the electronic fence based on image processing technology

5. Experimental Results

The system is implemented on standard PC hardware and works in real-time with more than 25 fps in C language after programming optimization. The video images sizes are from 800∗1024. Extensive experiments have been carried out on a recent dataset including various outdoor environments. Figure 6 shows the examples of one person of tracking results of our method, from which it can see that scale changes are common and the image algorithm designed in this paper can track people. In addition, every tracking object is assigned with a number, which is ordered following its occurrence sequence, so that we can explicitly observe the initiation, maintenance and deletion process of a tracking object.

Figure 6. Tracking experiment results

6. Conclusions

In this paper, we propose a simple but effective system to forewarn construction personnel who across the safety fence in power construction fields. The GMMs background subtraction is used to detect foreground objects in the first place. Then objects' motions are tracked by a two-part method including Kalman filtering and MHT, among which Kalman filtering is used for target prediction and MHT is used for data association between predictions and observations. Additionally, we use a multi-part color histogram representation and blob merging and splitting detection methods to improve the accuracy of target tracking. With these technologies, the system can provide real-time forewarning and alarm for construction personnel who across the safety electronic fence. The system has high computational efficiency, and the accuracy of the system is proved by testing various image sequences.

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