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A research on the airport monitoring intelligent recognition of terrorist violent actions

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ABSTRACT

It's very important to identify terrorists' behavioral features for the sake of airport security. Generally, the traditional method is targeted at personnel recognition of specific features of fixed scenes. The nonrestrictive characteristic of airport regions and the disguise of violent terrorists are left unconsidered. As a result, the recognition evolves into a high dimensional issue with increased difficulty in recognition. This paper presents a projection feature algorithm to identify the behavioral features of terrorists in an intelligent way. The researchers reconstruct the features of the original collected monitoring images. During reconstruction, the optimal cost function is selected to provide a proper data basis for accurate recognition. The reconstructed two-dimensional images are projected on the one-dimensional plane and transformed into the one-dimensional recognition issue. The recurrence relation is applied to categorize and recognize related violent terrorist actions with enhanced recognition accuracy and efficiency.

KEYWORDS

Airport; Intelligent recognition; Terrorist violent actions.

INTRODUCTION

To expand the violent terrorist influence, violent terrorists always choose to perform terrorist violence[1] on public sites, such as the railway station and airport with great flow density. Any occurrence of violent terrorist incidents at the international hub airport will exert seriously adverse international influence. Therefore, currently it's urgent for the civil aviation industry to meet the crucial demand for effective prevention from violent terrorism in airport regions[2]. The airport regional monitoring system is able to monitor the crowd within airport regions in real time and dynamically[3], providing important technical support for coping with emergencies[4].

It has been a hot issue of researches on airport security management to utilize the airport regional monitoring system for intelligent recognition of crowd actions involving terrorism[5]. At the present stage, there are three main methods for intelligent recognition of crowd actions involving violent terrorism in airport regions: 1. the method based on edge detection algorithm; 2. the method based on feature fusion; 3. the method based on Gaussian model. The last one based on Gaussian model is employed the most frequently[6].

However, as often discovered during the collection of crowd violent actions through the airport regional monitoring system, the fidelity of the collected violent terrorist action images is relatively low, because images tend to be impacted by a variety of factors, including illumination, the monitoring angle, the intentional disguise of terrorists, etc. The traditional methods for personnel recognition are based on the specific features of fixed scenes without considering the nonrestrictive characteristic of airport regions and the disguise of terrorists. As the recognition becomes a high dimensional issue of categorization and recognition, the crowd violent actions are identified less accurately with decreased timeliness.

Hereby the researchers present a method based on projection feature algorithm for intelligent recognition of crowd violent actions in airport regions. The features of the original collected monitoring images are reconstructed. During reconstruction, the optimal cost function is selected. The reconstructed two-dimensional images are projected on the one-dimensional plane and transformed into the one-dimensional recognition issue. The violent actions are hence identified with less time but improved accuracy.

RECOGNITION PRINCIPLE OF TERRORIST ACTIONS IN AIRPORT REGIONS

Subsequent to the collection of crowd action images through the airport regional monitoring system, the collected images should be pretreated in the first place to eliminate the influence of noise; recognition should be completed according to fixed features. The principle is stated as follows:

The airport crowd action images are divided into grids with the same size. The gray values of different grids are extracted. The mean gray value of images is used as the initial feature. The collected crowd action images are set to be divided into $K \times L$ grids $\zeta_{k,l}$. These grids can overlap. All grids are in the same size. The initial feature of crowd action images is $X = [x_1, x_2, ..., x_{K\times L}]$. The mean gray value of grids can be described by the following formula:

$$x_{(l-1)\cdot K+k} = \frac{1}{d_x \times d_y} \sum_{\Sigma \in \Gamma_{k,l}} I_Z \tag{1}$$

The prior probability of the mean gray value of grids is set as $p(x)$. The following formula can be used to describe the posterior probability of the mean gray value.

$$P(w \mid x) = \frac{p(x \mid w)P(w)}{p(x)} \tag{2}$$

In the formula, $p(w)$ is the revised probability.

With the above method, the collected crowd action images can be pretreated to remove the influence of noise and ensure the accurate recognition of violent terrorist actions.

Through the above pretreatment of the collected crowd action images, the standard images to be recognized are obtained. Then the features of crowd actions are identified. The specific methods are shown as follows:

The following formula is used to extract the features of crowd action images:

$$R(\theta)=\frac{1}{l}\sum_{t=1}^{l}L(X_t,\theta)=-\frac{1}{l}\sum_{t=1}^{l}\ln p(X_t,\theta) \quad \textbf{(3)}$$

The following Gaussian model is established in light of the above extraction results:

$$P(i \mid X_t,\theta)=\frac{\alpha_i P_i(X_t)}{\sum_{k=1}^{M}\alpha_k P_k(X_t)} \quad \textbf{(4)}$$

$P_i(X)$ is used to describe the D-dimensional Gaussian distribution of the crowd image features and α_i is its weight.

The images to be recognized are classified by a classifier through the constructed Gaussian model. The classification formula is listed as follows:

$$n^* = \arg MaxP(k \mid X) \quad \textbf{(5)}$$

In the formula, n^* refers to the recognition result of crowd action features.

Through the application of the above method, the features of crowd action images are extracted; the Gaussian model is constructed to classify the crowd actions; finally the action features of terrorist suspects are identified in an intelligent way. Nevertheless, in the traditional methods used for personnel recognition based on specific features of fixed scenes, the nonrestrictive characteristic of airport regions and disguise of violent terrorists are not taken into consideration. The recognition changes into a high dimensional issue with lowered accuracy and timeliness of crowd violent terrorist action recognition.

A VIOLENT TERRORIST PERSONNEL RECOGNITION METHOD BASED ON PROJECTION FEATURE ALGORITHM

When the traditional methods are adopted for intelligent recognition of crowd violent terrorist actions in airport regions, the collected images are affected by the weather, illumination, the monitoring angle and the intentional disguise of violent terrorists, etc. Thus the reliability of crowd action images and the recognition accuracy decline. Thereupon the researchers put forward a method based on projection feature algorithm for intelligent recognition of crowd violent terrorist actions in airport regions.

Reconstruction of crowd action image features

Set N samples of crowd action features, $V_1,V_2,...,V_N$; $V_i \in R^D, i=1,2,...,\mathrm{N}$. The following formula can be used to calculate the similarity between any two data samples of crowd action features, V_i and V_j .

$$S_{ij}=1/\left\|V_i-V_j\right\| \quad \textbf{(6)}$$

Here, $\|*\|$ is the norm of the two sample data of crowd action features.

The following formula can be used to calculate the average similarity between V_i and any other sample data of crowd action features:

$$M_i = \frac{1}{N-1}\sum_j \frac{1}{\|V_i - V_j\|} \quad (7)$$

In the formula, $j \le N$ and $j \neq i$. M_i is used to describe the threshold of neighbour selection. If the similarity between V_i, the crowd action features, and V_j, any crowd action feature sample data, is larger than M_i, then V_j is the close neighbour of V_i. If such similarity is not larger than M_i, then V_j is not the close neighbour of V_i. The formula (6) is only a part of the hyperbolic curve located at the first quadrant, namely the closer it is to V_i, the sample point of crowd action features, the larger S_{ij} is; the farther away it is from V_i, the sample point of crowd action features, the smaller S_{ij} is. Hence, the M_i value in the formula (7) should be closer to V_i to avoid the return circuit problem resulting from the overly large neighbour number of the crowd action feature samples. The formula (6) is a monotone decreasing function, so the number of neighbours of all crowd action feature samples should be determined by the dichotomy method as specifically shown in the following steps:

1) As to any crowd action feature sample V_i, the Euclidean distances between V_i and the rest of crowd action feature samples are sequenced in line with their size. The initial values are set as $\lambda_{\min} = 1$ and $\lambda_{\max} = N-1$;

2) $\lambda = (\lambda_{\min} + \lambda_{\max})/2$ is set. If the condition, $S_{i[\lambda+1]} \le M_i \le S_{i[\lambda]}$, is met, then turn to the step 4) directly; otherwise turn to the step 3) where $[\lambda]$ is the integer value of λ taken downward;

3) As to the similarity between V_i, the crowd action feature sample, and $V_{[\lambda]}$, if the similarity value is larger than M_i, then set $\lambda_{\min} = \lfloor \lambda \rfloor$; otherwise, set $\lambda_{\max} = \lfloor \lambda \rfloor$ and turn to the step 2);

4) Determine $\lambda_i = \lfloor \lambda \rfloor$ as the scope of neighborhood of V_i, the crowd action feature sample, and conclude the calculation.

The calculation method for the optimal cost function during image reconstruction

When the close neighbours of all crowd action feature samples are determined, such sample images can thus undergo the linear reconstruction. In case of the reconstruction error during image reconstruction, the quantization should be minimized. The following formula can be used to describe the cost function of reconstruction error.

$$\begin{aligned}\varepsilon(W) &= \min\left\| V_i - \sum_{j=1}^{\lambda_i} W_j^{(i)} V_{ij} \right\|^2 \\ &= \min\left\| \sum_{j=1}^{\lambda_i} W_j^{(i)} (V_i - V_j) \right\| = \sum W_j W_k G_{jk}\end{aligned} \quad (8)$$

Here, ε refers to the linear reconstruction error under the circumstance where V_i, the crowd action feature sample point, has k close neighbours, $V_1, V_2, ..., V_k$, used for sample image reconstruction. W_i^j and

G_{ij} are used to describe the reconstruction weight in the structural form of Gram matrix. The number of close neighbours used for reconstruction is different for each crowd action feature sample V_i. During the image reconstruction, each column of non-zero pixels in the matrix W differs greatly, namely the i column of W may have non-zero pixel values of λ_i only. Suppose G_{jk} is positive definite, there must be an inverse matrix G_{jk}^{-1}; the optimal reconstruction function of the optimal crowd action feature images can be acquired, as shown in the following formula:

$$W_j^i = \sum_{m=1}^{\lambda_i} (\mathrm{Q}_{jm}^{(i)})^{-1} / \sum_{p=1}^{\lambda_j} \sum_{q=1}^{\lambda_j} (\mathrm{Q}_{pq}^{(i)})^{-1} \quad \textbf{(9)}$$

As to $Q_{jm}^{(i)} = (V_i - V_{ij})^T (V_i - V_{im})$ for all $W_j^{(i)}$, the upper limit value of its cumulative sum is K. While each $W_j^{(i)}$ is calculated, the upper limit value of its cumulative sum λ_j may be different.

Intelligent recognition of crowd violent terrorist actions

The steps to identify the feature images of crowd violent terrorist actions through the projection feature algorithm should be taken as follows: first, the two-dimensional images of crowd actions are projected on the one-dimensional plane to transform the two-dimensional issue into the one-dimensional recognition; then the time of identifying crowd violent terrorist action features will decrease accordingly. On such basis and in accordance with the recurrence principle, the operation amount of crowd violent terrorist action feature recognition at each position and the recognition time to meet the real-time requirement of recognition are reduced.

The one-dimensional gray projection of crowd action images is to sequence the gray values in lines by taking the top left corner of the template image T as the origin and to calculate the mean by the following formula:

$$V(k) = \frac{1}{M} \sum_{m=1}^{M} T(m,k), \quad k = 0,1,2,..., \mathrm{N} \quad \textbf{(10)}$$

$G(x, y)$ is set as an $\mathrm{M} \times \mathrm{N}$ -sized crowd action image to be recognized (G for short); $\mathrm{g}(\mathrm{x}, \mathrm{y})$ is an $\mathrm{m} \times \mathrm{n}$ -sized crowd action template image (g for short). $\mathrm{g}_{i,j}$ is used to describe the sub-image, of the same size with g, extracted from the image G based on the origin (i, j). The following formula can describe the matrix to which the sub-image corresponds:

$$\mathrm{g}_{(i,j)}(s,t) = f(i+s-1.j+t-1) \ \mathrm{s} = 1,2,...,\mathrm{m}, \mathrm{t} = 1,2,...,\mathrm{n} \quad \textbf{(11)}$$

$\rho(\mathrm{i}, \mathrm{j})$ is set to be capable of describing the correlation coefficient between $\mathrm{g}_{i,j}$ and g.

After the acquisition of the one-dimensional gray projection of crowd action images, the one-dimensional matrix M in the length of n can also be obtained. During the crowd action feature recognition, $(\mathrm{M}-\mathrm{m}+1) \times (\mathrm{N}-\mathrm{n}+1)$ sub-images are extracted sequentially to go through the one-dimensional gray projection; then $(\mathrm{M}-\mathrm{m}+1) \times (\mathrm{N}-\mathrm{n}+1)$ one-dimensional matrices in the length of n can be obtained. The following formula can be used to describe the one-dimensional correlation coefficient of crowd action features:

$$R(i, j) = \frac{\mathrm{cov}(g_{i,j}, g)}{\sqrt{P(i, j) \times \mathrm{p}}} \quad \textbf{(12)}$$

G is set to be the gray image of crowd actions; T is set to be the template image of violent terrorist actions; $G_{i,j}(k)$ is the one-dimensional matrix corresponding to the gray projection of the sub-image of the same size with T and extracted based on the origin (i, j) from G. Then the following recurrence relation comes into existence:

$$\mathrm{P(i+1, j)} = \mathrm{P(i, j)} + \beta - \alpha^2 - 2\alpha\overline{G}_{i,j} \tag{13}$$

In the formula:

$$\begin{aligned} \alpha &= \frac{1}{n}\left[G_{(i+1,j)}(n) - G_{(i,j)}(1)\right] \\ \beta &= \frac{1}{n}\left[G_{(i+1,j)}(n)^2 - G_{(i,j)}(1)^2\right] \end{aligned} \tag{14}$$

With the above-illustrated method, the two-dimensional images of crowd actions are projected on the one-dimensional plane to cut down the time to identify the crowd violent terrorist action features. In accordance with the recurrence principle, the operation amount of crowd violent terrorist action feature recognition at each position is reduced to meet the real-time requirement of recognition.

EXPERIMENTAL RESULTS AND ANALYSIS

Simulation data and environment

An experiment was carried out to demonstrate the effectiveness of the algorithm presented by this paper. The experiment data were sourced from the authentic crowd violent terrorist image database of the airport regional monitoring system in some large hub airport. 1000 images of crowd violent terrorist actions were first selected randomly and divided into two groups with equal quantity. One group served as the training sample, namely the template images of crowd violent terrorist action features; the other group served as the testing sample, namely the crowd action images to be recognized. The experimental environment was the Windows 8.1 operating system with Pentium (R) Dual-Core CPU T4300 8.0GHZ. The experimental environment was constructed by VC++6.0 and Matlab 7.5.

Comparison of convergence speeds of different algorithms

To demonstrate the real-time effect of the algorithm presented by the paper on the airport crowd violent terrorist action recognition, a comparison was required between the respective recognition convergence speeds of the traditional algorithm and the algorithm presented by the paper. The recognition convergence curves of different algorithms were shown in Figure 1.

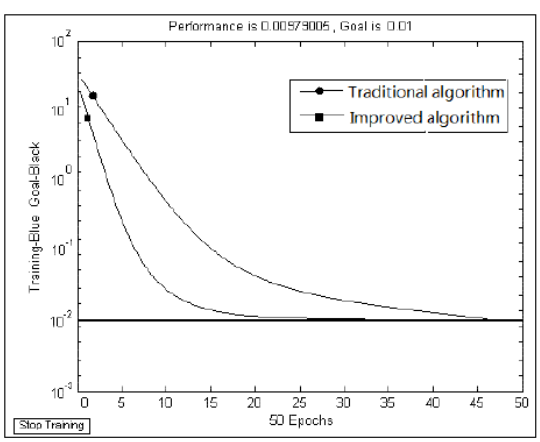

Figure 1: Comparison of convergence speeds of the traditional algorithm and the improved algorithm

The above experimental result revealed an obviously faster recognition convergence speed of the algorithm presented by the paper compared with that of the traditional algorithm. It fully proved the effectiveness of the improved algorithm, because the feature reconstruction of the collected airport regional crowd action images eliminated the influence of interference factors, transformed the two-dimensional feature recognition into the one-dimensional recognition issue, reduced the recognition time and increased the recognition speed.

Comparative analysis of recognition results from different algorithms

For further demonstrating the effectiveness of the algorithm presented by the paper, the recognition results of crowd violent terrorist feature images obtained through different algorithms were compared. During the recognition based on the traditional algorithm, the crowd violent terrorist action images were divided into 300×400 grids with the same size. The gray values within different grids were extracted. The mean gray value of images was used as the initial feature to construct the Gaussian model. Eventually the identified crowd actions were categorized by the classifier. During the recognition based on the algorithm presented by the paper, the first step was feature extraction of the crowd violent terrorist images in the image library. The threshold M_i for neighbour selection was set as 0.6 for the feature extraction of violent terrorist actions V_i. The sample images were projected on the one-dimensional plane. Subsequently through the gray normalization, the standard images to be recognized were thus obtained. These images with the same mean and variation were then classified and identified in terms of violent terrorist actions.
The recognition results based on the traditional algorithm were shown in Figure 2.

Figure 2: Recognition results based on the traditional algorithm

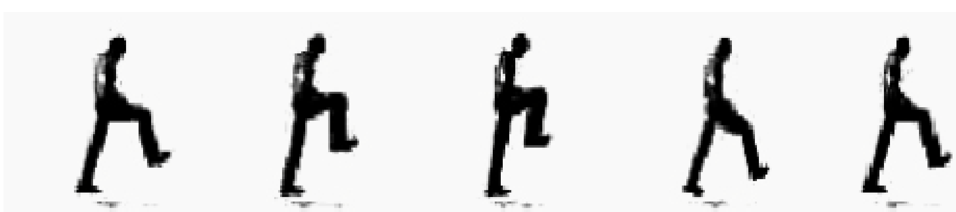

Figure 3: Recognition results based on the algorithm presented by the paper

It can be seen from the above recognition results, the traditional algorithm, without considering the multiple factors such as illumination, monitoring angle and intentional disguise of violent terrorists, led to the decline in recognition accuracy. Whereas the improved algorithm achieved higher recognition accuracy by extracting the original image features and eliminating the external interference. The experimental results were shown in TABLE 1, Figure 4 and Figure 5 based on the above experimental data.

The radar diagrams (Figure 4 and Figure 5) clearly displayed significant improvement in the efficiency and time for the crowd violent terrorist action recognition in airport regions based on the new method. Relative to the traditional method, the new one improved the recognition efficiency by an average 23% and the recognition speed by an average 12.2 seconds. The superiority of the algorithm presented by the paper was fully proved.

TABLE 1: Comparative analysis of experimental results

Varieties of Violent Terrorism	Number of Samples	Recognition Rate (%)		Time (ms)	
		Method 1	Method 2	Method 1	Method 2
Knife holding	200	67%	85%	21	13
Hitting	200	62%	94%	25	11
Kicking	200	69%	90%	32	16
Holding in the arms	200	82%	97%	26	18
Striking with the foot	200	59%	83%	27	12

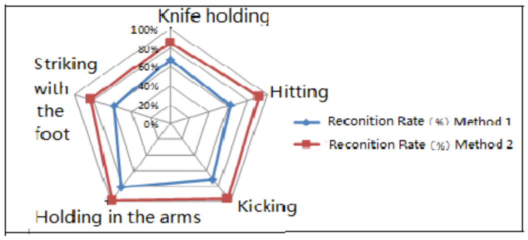

Figure 4: The radar diagram of recognition rate comparison between two methods

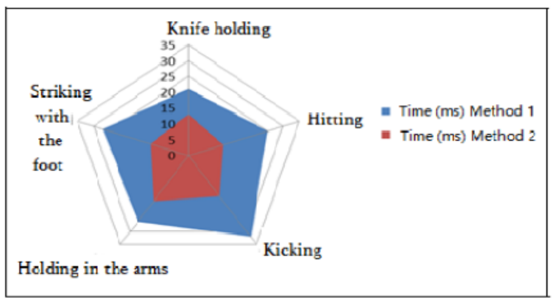

Figure 5: The radar diagram of time and efficiency comparison between two methods

CONCLUSION

The researchers in the paper proposed a method based on projection feature algorithm for intelligent recognition of crowd violent terrorist actions. The features of the original collected monitoring images were reconstructed. The optimal cost function was selected during reconstruction. The two-dimensional reconstructed images were projected on the one-dimensional plane. The transformed one-dimensional recognition issue reduced the recognition time and improved the recognition accuracy. The simulation experiment demonstrated the distinct advantages of such new algorithm compared with the traditional one. It furthered the accuracy and real-time effect of recognition and provided technical support for the security in airport regions.

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