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An Automatic Alarm Scheme of Video Security Monitoring System Based on Autocorrelation Function

Peilong Xu
The Growing Base for State Key Laboratory, Qingdao University, No. 308, Ningxia Road, Qingdao 266071, P. R. China

Abstract: This study presents an autocorrelation function-based program of dynamic image recognition and automatic alarm. Lighting effect analysis, binarization of the dynamic image and other methods were used to enhance the image; a dynamic image autocorrelation function was established to determine the threshold of automatic alarm system; and using Matlab software a simulation experiment was conducted on the autocorrelation function. The experiment showed that the correlation function value is inversely proportional to the amount of change of the video surveillance image; the autocorrelation function value can be used to determine when to trigger the automatic alarm system. This dynamic image recognition program, characterized by strong stability and little impact from the outside, can be used for automatic alarm of monitoring system.

Keywords: Autocorrelation function, image processing, monitoring system

INTRODUCTION

Video monitoring system is a kind of alarm system based on dynamic signal transmission. Nowadays, video monitoring system has played an important role in the public security. Especially the system using the infrared signal as the light source can also achieve the clear dynamic image, so it is very prevalent.

Although the previous video monitoring system can achieve multisite dynamic monitoring, it needs a large number of people to monitor (Jian *et al.*, 2012). This requires a lot of labor forces and material resources and sometimes in an emergency, because the person on duty is focusing on other area, it is easy to cause the omission. At the same time, due to the instability of the video transmission, it is difficult for the people to recognize and to realize the automatic alarm for the suspicious circumstances. The video monitoring system plays an important role in urban security, traffic information construction, financial monitoring, production safety and other aspects. The data show that from 2004 to 2012 the market size of the digital surveillance system grows rapidly at an average annual rate of 46.3%. The original alarm monitoring system relying on visual identification of the monitoring personnel has been overwhelmed, thus the video surveillance system with automatic alarm function comes into being. Early automatic alarm-featured monitoring system mostly relied on optical or infrared sensor alarm. These alarm systems had such disadvantages as high rates of false and missing report and difficulties in specific target identification (Sahoo, 2011).

For the drawbacks of the old-fashioned alarm systems, this study using image processing technology designed an autocorrelation function that can realize automatic alarm relying solely on image recognition and carried out a simulation experiment on the system.

METHODOLOGY

The basic method of this automatic alarm system for video surveillance: identified the change of the dynamic image relying on data and image binarization and interframe differentiation after the enhancement and then set a threshold value according to the change of the image and by threshold value determination realized the image-based automatic alarm (Koltsov, 2011). The specific program is shown in Fig. 1.

Image denoising: Outdoor surveillance system needs to work in different light conditions. Due to the CCD characteristics, images in low light conditions easily produce more noise. Therefore, before image recognition, the denoising must be done first (Hilgersom and Luxemburg, 2012). There are mainly two kinds of dynamic image denoising algorithm-mathematical morphology method and median filtering algorithm. A number of experiments prove that mathematical morphology method plays a certain role in image de-noising without blurring the image, thus basically meets the requirements, but its drawback is that the image after denoising treatment is not smooth enough, while image denoising using median filter leads to very smooth image and effectively reduces the number of video streams after compression and synthesization, but due to little difference in brightness value between noise and the image information around of the image in low light conditions, the image after denoising treatment, due to loss of information, is not clear enough.

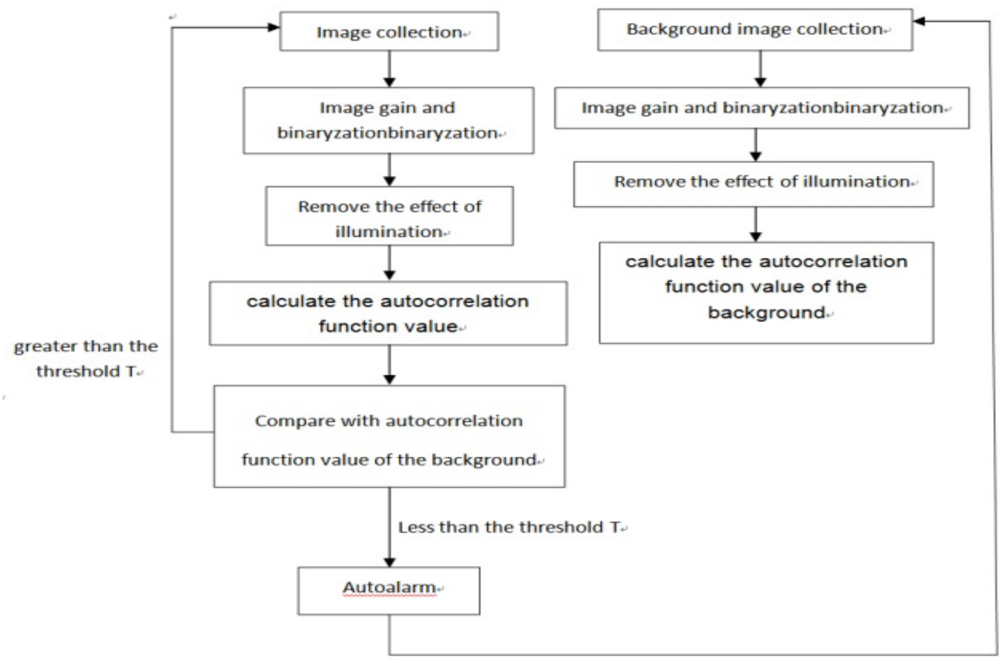

Fig. 1: Specific program of image-based alarm

This study for images in low light conditions proposes a new algorithm design philosophy: first, use digital morphology method to filter out some of the noise, while using mathematical morphology method's clustering function to gather image information as a relatively concentrated part and then use the median filter to treat the image, so that the image becomes relatively smooth, but to this point due to the image information relatively concentrated, the part of image information contains only little noise, so in the denoising process not too much information will be lost and the image after processing is relatively clear (Murthy *et al*., 2011.). According to the above method, a better denoising effect can be obtained.

Motion detection algorithm: On target motion detection, interframe difference threshold method was used to complete the identification of the target state (Siriteerakul, 2012). First, frame differentiation was done between two neighboring images in the image sequence and then the gray scale differential image was binarized to calculate whether there is a moving target intruding into the screen. Formula (1) gives conditions to determine whether there is an object intruding into the screen:

$$\sum_{(x,y)\in P} \left| f(x,y,t) - f(x,y,t+\Delta t) \right| > T \qquad (1)$$

where, as P stands for image capture area, f (x, y, t) for the gray-scale values of the image sequence at time t (x, y), where time t is discretized, Δt for interval between images. When Δt is larger, the recognition rate of fast-moving object will reduce, so will the overall system sensitivity, but the system computing resources are saved. When Δt is smaller, the system sensitivity will correspondingly increase, but system resources occupancy rate will be high.

Overcome the impact of sunlight on effect judgment: Video surveillance system in the outdoor environment is often affected by the impact of changes in sunlight of different time periods. It is observed that light changes generally occur evenly, so does the overall image gray scale change (James *et al.*, 2006). Therefore, when only the illumination changes, the difference between the pixels is more concentrated; when a moving object enters, the difference between the pixels will be more dispersed. According to the principle described above, a threshold value Tn was set. Not until the situation listed in Formula (2) occurs will the system sound an alarm; otherwise, the system determines the situation as illumination change:

$$\sum_{(x,y)\in P} N[\left| f(x,y,t) - f(x,y,t-\Delta t) \right| - (\frac{\lambda}{n} \sum_{(x,y)\in P} \left| f(x,y,t) - f(x,y,t-\Delta t) \right|)] > T_n$$
$$N(x) = \begin{cases} 1, & x > 0 \\ 0, & x \le 0 \end{cases} \qquad (2)$$

where as:

$$\frac{\lambda}{n} \sum_{(x,y)\in P} \left| f(x,y,t) - f(x,y,t-\Delta t) \right|$$

is the threshold value entry, representing the overall change of light; λ is adjustment coefficient; n is the number of pixels within the detection area.

Autocorrelation function of the alarm: After the above image processing, whether there is moving object intrusion can be determined. The basic theory of the autocorrelation function:

- Set the images collected by the safety monitoring system as odd and even fields
- Establish function for each row of pixels of every image
- Determine the amount of change of the overall image through interframe comparison of each row of pixels
- Set threshold in accordance with the specific requirements to determine whether the monitoring system should sound an alarm

Trough image gain and elimination lights influence, the binary images are converted to gray images.

The mathematical formula of the acquired image signal is X(t) = X_e(t) + X_0(t). The Xe(t) is even field signal and its value is shown in formula 3:

$$X_e(t)=\sum_{i=0}^{M-1}\sum_{k=0}^{(N-1)/2}\sum_{l=-\infty}^{\infty}x[iM_5,2kN_5,lT_p] \bullet \sin c\left\{2w[t-(i+kM+lNM)T]\right\} \tag{3}$$

The X0(t) is odd field signal and its formula is 4:

$$X_e(t)=\sum_{i=0}^{M-1}\sum_{k=0}^{(N-1)/2}\sum_{l=-\infty}^{\infty}x[iM_5,2k(2K+1)N_5,lT_p] \bullet \sin c\left\{2W[t-(i+kM+lNM+\frac{M(N+1)}{2})T]\right\} \tag{4}$$

In this formula, W is the highest frequency of the image signal and the sampling period is T = W/2.

So the autocorrelation function of the image acquired by the safety monitoring system is （shown in formula 5):

$$R_\tau = R_{\tau 1}R_{\tau 2}R_{\tau 3} \tag{5}$$

Through the analysis of the autocorrelation function, it can be concluded as follows:

The real space image can be scanned into one dimension function, so all of the autocorrelation function can be transformed into τ function. Rτ1 reflects the correlation of the inline. The other two directions are regarded as the constants and the direction of m is considered as stochastic. And then find out the Rτ1. When αequals to kTL, the Rτ1 get the extremum value, namely, Rτ1 = 1. In other position, Rτ1 declines as the e index law to the sides. The decrease speed depends on the parameter αn. Because the one dimension scanning signal is periodic, Rτ1 shows the trait of periodicity. shown in formula 6:

$$R_{\tau 1}=\sum_{k=-\infty}^{\infty}\exp\left[-a_m\left|\tau-kT_L\right|\right] \tag{6}$$

Rτ2 reflects the correlation of the interval. According to the formula of Rτ2, there will be a relative peak every other frame. But because the TV signal is scanned interlacedly, there will be another related peak in the even field and odd field besides in the even field and even field, odd field and odd field. So they have great relationships. shown in formula 7:

$$R_{\tau 2}=\sum_{l=-\infty}^{\infty}\left\{\begin{array}{l}\exp\left[-a_m\left|\tau-lT_P\right|\right]\\ +C\bullet\exp\left[-a_m\left|\tau-(l+\frac{1}{2})T_P\right|\right]\end{array}\right\} \tag{7}$$

Rτ3 reflects the correlation of the interframe and has no periodicity. Shown in formula 8.Rτ is the product of the three items. Product can be considered as the modulation of every item in mathematics. Because the periodicity of Rτ1 is smaller than that of Rτ2, it can be regarded that Rτ2 modulates the wave of Rτ1 and then gets modulated by Rτ3.

$$R_{\tau 3}=\exp[-\beta\left|\tau\right|] \tag{8}$$

EXPERIMENT AND RESULTS

Experimental equipment: The experiment used camera HikVision DS-2CZ292P as image acquisition component with basic parameters: 36X optical zoom, 540-line color CCD, minimum illumination, color 0.2Lux; black and white 0.02 Lux, signal-to-noise ratio greater than 52dB. The acquisition equipment was digital acquisition card HikVision DS-4216HC with main parameters: 16 BNC (level 1.0Vp-p, impedance 75Ω), using H.264 compression standard, playback resolution 4CIF. Graphics workstation was Lenovo Thinkstation E30 7824A36 with main parameters: Intel Xeon E1220 CPU; Nvidia Quadro 400 512MB graphics card.

Image denoising: Matlab 7.0 was used to write the image denoising program and then Matcom was used to compile the program into VC + +; the image 1.jpg acquired was treated with denoising. Matlab program is as follows:

Fig. 2: Image denoising effect

I1 = imread ('1.jpg'); %Read the grey image.
I2 = imnoise (I1,'salt & pepper'); % Add salt and pepper noise in image.
Figure, imshow (I2)% Display image with the salt and pepper noise.
I3 = im2bw (I1); % Convert image with the salt and pepper noise into binary gray image.
Figure, imshow (I3) % display binary gray image.
I4 = bwmorph (I3,'open'); % operate the binary noise image with Morphological opening operation.
Figure, imshow (I4)% display image after opening operation.
I5 = bwmorph (I4,'close'); % do Morphological closing operation to the above image.
Figure, imshow (I5)% display the processed image.
The denoising effect is shown in Fig. 2:

In the figure, A is the initial image (added salt and pepper noise), B is the effect image using digital morphological method and noise reduction，C is the effect image of B after median filtering operation.

Determination of the threshold value in case of intruding object: The main purpose of the present experiment is to determine the threshold value of alarm trigger in case of intruding objects. The method of environment:

- At a distance from the camera of 30, 20 and 10 m, respectively, used a small car for intrusion experiment and then, respectively calculated the autocorrelation function value to determine the threshold of alarm trigger in case of small car intrusion

Table 1: Rτ in several conditions calculated by the autocorrelation function

Invasion object	Distance	Rτ value	Background Rτ value	Change rate of Rτ value (%)
Car	30 m	0.429	1.145	62.25
Car	20 m	0.331	1.128	70.66
Car	10 m	0.209	1.131	81.52
Personnel	15 m	0.511	1.193	57.17
Personnel	10 m	0.423	1.176	64.03
Personnel	5 m	0.385	1.149	66.49

- At a distance from the camera of 15, 10 and 5m, respectively, let the experimenter enter the monitoring range and then calculated the autocorrelation function value, respectively

To determine the alarm trigger threshold in case of intrusion by various objects, Matlab 7.0 was used to write the autocorrelation function program:

R1 = R1+exp(-am*abs(t-tl))
R2 = R2+exp(-am*abs(t-tp))+C*exp(-am*abs(t-(l+1/2)*tp))
R3 = exp(-b*abs(t))
R = R1 * R2 * R can 3

According to the above experimental method, after the calculation of the image using Matlab image tool, the resulting data are shown in Table 1.

The experimental results show that at a distance of less than 30 m from the camera, in case of vehicle intrusion, the autocorrelation function value should be less than 0.429; in case of personnel intrusion within 15 m from the camera, the auto-correlation function values should be less than 0.511. The background values reflected the autocorrelation function value before any object intrusion. As can be seen in Table 1, in the above-mentioned several cases, the change rate of the autocorrelation function was more than 50%, which proved that the autocorrelation function has better robustness. According to the reference values of this study, the trigger threshold of monitoring system can be determined as per the specific requirements of the user.

CONCLUSION

This study designed a video monitoring automatic alarm scheme realized by methods of image procession. Experiments results shows that this scheme has the advantages of fast reaction rate, simple installation, small external interference etc. and the system overall performances are excellent. But the scheme still needs improvements in the following aspects:

- In condition of monitor be sheltered in short distance, for example insects passing by, false alarm might happen because the shelter object occupies a larger proportion of the picture.
- The background updates after alarm, so that after the system finished the first alarm, false alarm

might happen because of the background will be unstable in a short period.

- Since the scheme used whole image calculation method, which is highly time complexity, the system requires high calculation speed hardware to support the operation. These problems need to carry out further researches to overcome effectively.

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