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Study of the Video Monitoring System Image Recognition Solutions Based on Mathematic models

Peilong XU[1], Cheng ZHANG[2]

[1] The Growing Base for State Key Laboratory, Qingdao University, No. 308, Ningxia Road, Qingdao 266071, China.

[2] Office of Facilities and Laboratory Management, Qingdao University, Qingdao, China.

Abstract

objective: Through establishment a set of image recognition system based on mathematic models, to develop a auto alarm solution for the video monitoring system. Methods: compare the images the video monitoring system collected according to the time sequences. Then after binaryzation and wave filtering, the images were converted into numerical values using autocorrelation function, and the alarm threshold value was confirmed by experiences. Results: Through experiments, the change ratios of the two images before and after image processing were inversely proportional to the autocorrelation function. When the function value is less than 0.8, it indicates that there is an object volumes larger than 1m3 has invaded into 15m distances, and when the function value is less than 0.6, it indicates that there is an object volumes larger than 1m3 has invaded into 30m distances. Conclusion: Through calculation of autocorrelation functions, auto alarm for the images collected by video monitoring system could be effectively realized.

Keywords: *Video monitoring system, Autocorrelation function, Image processing Mathematic models.*

1. Introduction

Dynamic image recognition and self alarm is a key point in monitoring system studies for many countries, and the research fruits have been used in public safety areas widely. Now, public safety agencies in every countries are seeking an auto alarm system for video monitoring system which could not only save labor forces, but also decrease rates of false and leak alarms. But because of the imperfect of motive images recognition methods, the existing solutions are high in time complexity. The present automatic alarm systems mostly distinguish the object by perceiving the sound, light reflection signals or heat radiation, such as vehicle installation back-draft radar and so on. However, the object recognition rate for the objects with no reflection signal or far heat radiation is not high. Our study combines with the image processing technology and develops an alarm system based on the graphics change mathematical model. This is a good way to solve the above problems.

2. The Automatic Alarm Image Recognition Scheme and Method Of The Video Security Monitoring System

2.1 The network structure of the video security monitoring system with the function of automatic alarm

The safety monitoring system includes the following several parts: monitoring camera equipment, coaxial cable used for the transmission of analog signal, DVR hard disk video camera, graphics workstations equipped with a video acquisition card, video matrix distributor, TV wall. The system acquires the analog video signal using various forms of industrial camera. And the analog signal is transmitted to the DVR hard disk video cameras and video collection card through the double loop line, respectively. The image acquisition card acquires an image after a certain time according to the sampling rate. Though the binarization of the image, the computer stores the document in the bitmap file format to the hard disk for processing. The real-time images are displayed in the TV wall, and at the same time, the system warns about the alarm area and sends the discriminant result to the user terminal through the Internet. DVR hard disk video camera records all the images. Fig. 1 shows the network topological structure of the video safety monitoring system.

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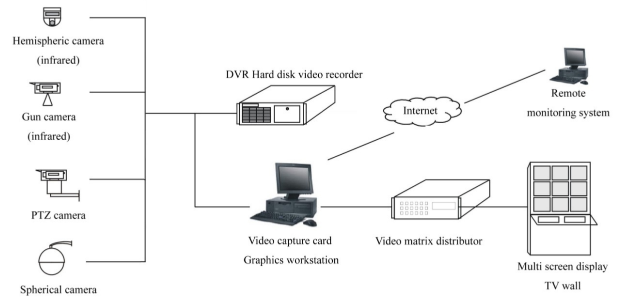

Fig. 1 the network topological structure of the video safety monitoring system

2.2 The basic scheme of the image recognition

The images stored in the hard disk are removed the color information, and make the gain processing. Then the two adjacent images are compared, and through the judgment of the autocorrelation function for the adjacent images, it can be told whether someone or other alien come into the monitoring area.

2.3 The method of image gain processing

Due to the difference of the image acquisition devices and the difference of the environment, some noise cannot be avoided in the direct image. So the images should experience the gain processing before the comparison and identification. Among many filtering processing methods, the system chooses the following two methods:

(1) Neighborhood average method: the basic thought of this method is to get the average value A' of the point A pixel and point B pixel's gray value in the image. Then replacing the point A's gray value uses the valve A'. It is assumed that the coordinate of the image pixel point A is (x, y) and its gray value is f (x, y). The size of neighborhood S is the size of L×W and after the neighborhood average processing, the gray value g(x, y) of the image is (1).

$$g(x,y)=\begin{cases}\overline{f}(x,y) & |f(x,y)-f(x,y)|>T\\ f(x,y) & other\end{cases} \tag{1}$$

In this formula, T is the given threshold (2).

$$\overline{f}(x,y)=\frac{1}{LW}\sum_{(x,y)\varepsilon S} f(u,v) \tag{2}$$

This processing is effective to the light and dark point noise produced during the processing of image sensor, transmission channel, decoding. At the same time, it can also make a smooth transition for the images only having some small differences.

(2) Median filtering is based on the order statistic theory and is a nonlinear signal processing technology which can reduce the noise effectively. Its basic principle is replacing the value of a point in the digital image or in the digital sequence with the mid-value of the every point value in its adjacent domain. This method can get the pixel value closed to the true value and eliminate the isolated noise point. Its outstanding merit is that it can protect the boundary information in the processing of noise elimination. However, its efficiency becomes lower and lower with the increase of the noise. So the median filtering is not suitable when the number of the noise pixel is more than half of the pixel.

In the digital image system, the typed images are acquired firstly, and then transformed into the electrical signals by scanning. After this, the signal can be used to store and compare. Finally, a new restored image is shown to the user. In this process, the high Gaussian noise is usually produced. Moreover, due to the limit of the processing speed for the dynamic image acquisition system, the system is unfavorable to use complicated method. In this system, the neighborhood average method is employed due to its lower time complexity. This method can remove the Gaussian nose efficiently and keep the edge of the image well.

2.4 Gray level expansion

Because the contrast of the darker area is very poor for the infrared image in the night, it is difficult to distinguish without processing. The grays level should be stretched in the image contrast in order to improve the grayscale dynamic range in the image processing. The treatment process is as follows. The range of the gray level for the image f (x, y) is [a, b]. The dynamic range of the transformed image g(x, y) is [c, d]. This transformation can be realized as the following formula (3):

$$g(x,y)=\begin{cases} c & f(x,y)<a\\ \dfrac{(d-c)[f(x,y)-a]}{b-a}+c & a\le f(x,y)\le b\\ d & f(x,y)\ge b\end{cases} \tag{3}$$

This piecewise transformation will elongate the original grey interval [a, b], but compress [0, a] and [b, 255]. If there are only a few of points in the interval, this transformation is reasonable.

2.5 The autocorrelation function of the safety monitoring system image

The image collected by safety monitoring system is transformed into the black and white image after the gain and gray level expansion processing. The mathematical formula of the acquired image signal is (4)

$$X(t) = X_e(t) + X_0(t) \tag{4}$$

The Xe(t) is even field signal and its value is (5)

$$X_e(t) = \sum_{i=0}^{M-1}\sum_{k=0}^{(N-1)/2}\sum_{l=-\infty}^{\infty} x[iM_5, 2kN_5, lT_p] \bullet \sin c\{2w[t-(i+kM+lNM)T]\} \tag{5}$$

The X0(t) is odd field signal and its formula is(6):

$$X_e(t) = \sum_{i=0}^{M-1}\sum_{k=0}^{(N-1)/2}\sum_{l=-\infty}^{\infty} x[iM_5, 2k(2K+1)N_5, lT_p] \bullet \sin c\left\{2W[t-(i+kM+lNM+\frac{M(N+1)}{2})T]\right\} \tag{6}$$

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 (7)(8)(9)(10)

$$R_\tau = R_{\tau 1} R_{\tau 2} R_{\tau 3} \tag{7}$$

$$R_{\tau 1} = \sum_{k=-\infty}^{\infty} \exp\left[-a_m\left|\tau - kT_L\right|\right] \tag{8}$$

$$R_{\tau 2} = \sum_{l=-\infty}^{\infty} \left\{ \begin{array}{l} \exp\left[-a_m\left|\tau - lT_P\right|\right] \\ +C \bullet \exp\left[-a_m\left|\tau-(l+\frac{1}{2})T_P\right|\right] \end{array} \right\} \tag{9}$$

$$R_{\tau 3} = \exp[-\beta|\tau|] \tag{10}$$

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

(1) The real space image can be scanned into one dimension function, so all of the autocorrelation function can be transformed into τ function.

(2) 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 α equals 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.

(3) 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.

(4) Rτ3 reflects the correlation of the interframe and has no periodicity.

(5) 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.

2.6 Activation Mechanism of the Alarm System

The alarm of this system is completed depending on the autocorrelation function calculation. The value got by the function is in an inverse ration of image date change. Therefore, the alarm activation can be achieved by setting a threshold value. But if the monitor camera is sheltered by something, the pictures will drastically change, such as the leaves falling down. It can also active the alarm system. In our research, the physical method is temporarily used to solve this false, such as the necessary protection of the camera.

3.Experimental Method and Results

3.1 System Information

The image processing uses the WV-CW860B/CH all-weather integration camera produced by Toshiba Company. And the image collection uses the AP-6816-4 acquisition card produced by APYLJ Company. The camera can work in the infrared and visible light modes. Because the automatic alarm function of video monitoring system is usually open in the night, the infrared acquisition mode is used to test. The AP-6816-4 acquisition card uses the 10 Bit 6816 chip, and the resolution of the image collection is set to PAL mode, which is 704×576.

The "Symbolic Math Toolbox" in Matlab software produced by the Mathworks Company USA is employed to transform the formula into the program of Matlab. Then through the Matcom software, the program of Matlab is transformed into the C++ program codes .

3.2 Noise Reduction of Image Filtering

During the process, the image gets gain process first, and then experiences gray level expansion. In order to ensure the image processing speed, Dell Precision T7500 graphics workstation is employed to process the image. This graphic workstation can ensure the processing speed to 20 FPS (frame per second). The image IMG001.jpg is processed by neighborhood average method using Matlab 7.0 software. The 5×5 neighborhood average and neighborhood standard deviation is calculated by nlfilter function. The program written is as follows:

```
figure;
a=imread('e:\test3_1.jpg');
a=im2double(a);
f1 = inline('max(x(:))');
f2 = inline('std2(x)*ones(size(x))');
A1 = nlfilter(a,[5 5],f1);
subplot(1,3,1);
imshow(a);title('input image');
subplot(1,3,2);
imshow(A1);title ( The 5×5 image after the neighborhood average) ;
A4 = blkproc(a,[ 5 5 ],f2);
subplot(1,3,3);imview(A4,[]);% (neighborhood standard deviation image)
```

In the test, the fuzzy figure A becomes to a clear figure B after the gain and gray level expansion processing which is shown in Fig. 2.

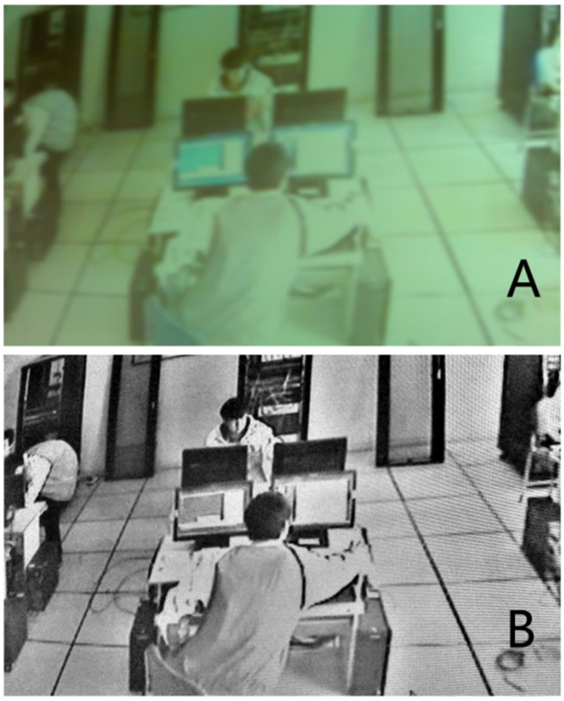

Fig.2. The Effect Image After The gain and Gray Level Expansion Processing.

3.3 The application of the autocorrelation function in alarm system

According to autocorrelation function calculation formula of the safety monitoring system image, the formula is programed by Matlab as follows:

```
R1 = 0;
R2 = 0;
for k = -inf:inf
R1 = R1 + exp(-am*abs(t-tl));
end
for l = -inf:inf
R2 = R2 + exp(-am*abs(t-tp)) + C*exp(-am*abs(t-(l+1/2)*tp));
end
R3 = exp(-b*abs(t));
R = R1 * R2 * R can 3;
```

After the operation and correction, the program can be changed into C++ program code using Matcom and applied into the system. The human body and the 1 m^3 carton are used to intrusion test for the video monitoring system. Table 1 shows the results of the intrusion test.

Table1 the autocorrelation function change result of the adjacent images

Invasion object	***Distance***	Rτ Value
person	10m	0.310
person	20m	0.461
Person	30m	0.562
Carton	5m	0.610
Carton	10m	0.671
Carton	15m	0.735
None		1.158

The experimental results show that the value Rτ and the image difference are inverse ratio, the smaller the value Rτ and the larger the image difference. Through the test, among the images taken by the camera, when the Rτ⩽0.6, the human body size object invades in the range of 30 m; when the Rτ⩽0.8, 1 m^3 size cube invades in the range of 15 m.

4. Conclusions

This study established a set of mathematic model for collection, compare and recognition of dynamic images. The experiments indicate that through calculation of autocorrelation functions, auto alarm for the images collected by video monitoring system could be effectively realized.

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First Author Peilong XU, born in 1977. The author has achieved Master degree from Tongji University of Shanghai in 2007. He is currently an engineer of computer science in the State Key Laboratory, Qingdao University. The author's research interests include software engineering, image processing, and spectral analysis. Recently, he have published paper named Design and Implementation of Landscape System for East and West Huashi Street in Beijing Based on Virtual Reality Technology on journal Applied Mechanics and Materials （ Trans Tech Publications Inc, Switzerland） etc.

Second Author Cheng ZHANG, Office of Facilities and Laboratory Management, Qingdao University, Qingdao, China.