ELSEVIER

Available online at www.sciencedirect.com

SciVerse ScienceDirect

Procedia Engineering 29 (2012) 2705 – 2709

Procedia Engineering

www.elsevier.com/locate/procedia

2012 International Workshop on Information and Electronics Engineering (IWIEE)

Three-Frame Difference Algorithm Research Based on Mathematical Morphology

Yanzhu Zhang[a], Xiaoyan Wang[a,b]*, Biao Qu[b]

[a]*Information Science and Engineering College Shenyang Ligong University, Shenyang Liaoning 110159,China*
[b]*Xiamen Institue of Technology Huaqiao University, Xiamen Fujian 361021, China*

Abstract

Because of the features of moving target, such as strong speed degeneration and uncertain route, it becomes hard to detect and track the moving target. Although there are many detecting methods for moving target, the noise of detection affects the detecting precision dramatically. In this paper, we extract target by three frame subtraction, and then process the extracting image by the method of mathematical morphology. By this method, the moving target can be detected effectively and the noise is eliminated dramatically. The experimental results show that this method has less calculation amount, higher real-time performance and higher accuracy for moving target detection, and this method can be well applied outdoor.

Keywords: object detection; three-frame difference; dilation; erosion

1. Introduction

With the development of information technology, people apply digital video more and more extensively [1-3]. Moving target detection and tracking is a very important application direction [4]. Moving target detection technology distinguishes moving objects and background, and extracts the moving target from digital video, which apples to the bank, highways, residential and other intelligent monitoring system. The results of moving target detection will directly affect the effect of moving target tracking.

* Corresponding author. Tel.086-13940303822: .
E-mail address: xiaoyan_wang@live.cn.

doi:10.1016/j.proeng.2012.01.376

At present, there are many methods of moving object detection, such as background subtraction, optical flow [4] and frame difference [5,6] , which are commonly used. The method of background subtraction should establish a model of background image from video first, and then get the moving target by comparing each frame image and background image. This method needs to consider the representation and initialization of background model, and the method of updating the background model. The main task of optical flow method is to calculate the optical flow field, i.e. under the conditions of smoothness conditions, estimates moving field by the space-time gradient of image sequence, and separates the moving target from background image by analyzing the change of the moving field. However, this method has not only complicated calculation, but also poor anti-noise performance, which makes itself be applied in real-time monitoring not well. The method of frame difference sets a threshold by comparing two adjacent frames of image, and considers the pixels are moving target as long as the difference is bigger than the threshold. Owing to the advantages of small calculations and high performance of real-time, this method is commonly used in object detection [5, 6]. However, most object detection methods have lots of noise. To solve this problem, we take advantage of three-frame difference to detect moving object, and utilize mathematical morphology to optimize the results of target detection, which are realized by MATLAB in this paper. Detecting object by frame difference

For the video sequence which is shooting by a stationary camera, we make smooth denoising for frame k and frame k+1 first, and then treat them by frame difference, i.e. frame k subtracts frame k+1, and we can get a binary image $D(x,y)$, which is expressed as follows:

$$D(x,y)=\begin{cases}1, & |f_k(x,y)-f_{k-1}(x,y)|\ge T\\ 0, & |f_k(x,y)-f_{k-1}(x,y)|< T\end{cases} \tag{1}$$

Where, T is the threshold which can be set previously according to our experience.

If the selection of T is too large, the goal of detection may becomes a vacancy even been missed. On the contrary, there will been lots of noise. From the formular of frame difference, it can be seen that, if the moving object is in uniform motion, the moving target detected according to the method of frame difference would be the same one. If the moving object accelerates or decelerates, the detection result gives more or less numbers than the reality. In addition, the moving target detected by the method of frame difference contains information of two frames. In order to overcome the disadvantage of the method of frame difference, three-frame difference has been proposed [7].

The first step of three-frame difference is to make smooth denoising for three consecutive frames, and then process them by the method of frame difference respectively, i.e. frame k subtracts frame k-1, and we can get a binary image $D_1(x,y)$, frame k+1 subtracts frame k, and we can get a binary image $D_2(x,y)$, and the final step is to make an and operations of $D_1(x,y)$ and $D_2(x,y)$, the result is three-frame difference image $D(x,y)$, which can be expressed as follows:

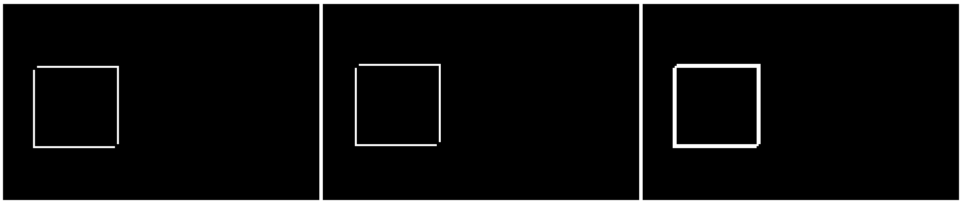
$$D_1(x,y)=\begin{cases}1, & |f_k(x,y)-f_{k-1}(x,y)|\ge T\\ 0, & |f_k(x,y)-f_{k-1}(x,y)|< T\end{cases} \tag{2}$$

$$D_2(x,y)=\begin{cases}1, & |f_{k+1}(x,y)-f_k(x,y)|\ge T\\ 0, & |f_{k+1}(x,y)-f_k(x,y)|< T\end{cases} \tag{3}$$

$$D(x,y)=\begin{cases}1, & D_1(i,j)\cap D_2(i,j)=1\\ 0, & D_1(i,j)\cap D_2(i,j)=0\end{cases} \tag{4}$$

Figure 1 explains the principle of frame-difference method. Figure 1(a), figure 1(b) and figure 1(c) are three consecutive frames, and the results obtained by the method of two-frame difference are shown in figure 1(d) and figure 1(e), and the result which comes from the method of three-frame difference is shown in figure 1(f). From these figures we can see that the result of three-frame difference is much closer to the real moving target than that of two-frame difference.

(a) frame k-1 (b) frame k (c) frame k+1



(d) frame difference of frame k-1 and frame k; (e) frame difference of frame k and frame k+1; (f) three-frame difference

Fig. 1. the principle of the method of frame difference

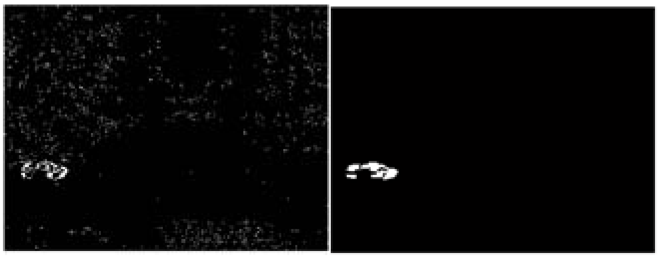
Three-frame difference method is applied by Grzegorz M. Wojcik et al. in their paper[8]. The procession of They use front frame subtracts middle frame, use middle frame subtracts last frame, and define the overlap of two difference image as the edge of moving target of middle frame. This can effectively solve the block problem of front and rear frames. Qiulin Li et al.[9] detect the moving vehicles by the method of combining three-frame difference method and two-dimensional cross-entropy threshold. Because of the three-frame difference method fully takes into account the temporal correlation of moving pixels, and is more sensitive for dynamic detection, and can also inhibit random noise effectively. However, there are some shortages of three-frame difference, such as the threshold often be set by hand, and most of time, the value of threshold be set according to our experience.

2. Frame difference method based on mathematical morphology

In this paper, we use improved frame difference, i.e. three-frame difference, to detect moving target first. When we get the binary image, deal it by dilation and erosion which is belong to mathematical morphology. In others paper, if they use the method of mathematical morphology, they usually use the method of open, close or other more complex methods to improve the result. However, in this paper, we only use erosion and dilation which the simplest method of mathematical morphology. Because whether it is opening or closing operation, it is composition by a pair of erosion and dilation operation, and the structuring elements of erosion and dilation are the same. However, if we deal the image with the method of erosion and dilation, we can change the structuring elements according to our need. Compared with other methods of mathematical morphology, dilation and erosion are easier in method and lower in computational than the others. At the same time, these two methods' structuring element can be controlled easily. As a result of this, we can remove noise, fill the empty of target, get the best consequence with the less time.

In this experiment, we detect the moving object which is shoot outdoor. Figure 4 shows the detection of a outdoor moving car. Figure 4(a), figure 4(b) and figure 4(c) are three consecutive frames, figure 4(d) is the result of detect by three-frame difference, figure 4(e) is the result of detect which use in this paper. From figure 4(d) and figure 4(e), we can know that, the method which be used in this paper is better than the method of three-frame difference. This method not only reduce the effect of strong changes in the external light, remove the noise of detect, but also detect the moving target clearly. Compare figure 4(d) and figure 4(e), we can find that this method has less calculation amount, higher real-time performance and higher accuracy for moving target detection, and this method can be well applied outdoor. We can get a target with a clear outline by this method.

(a) frame 51 (b) frame 52 (c) frame 53



(d) three-frame difference (e) method in this paper

Fig. 2. detection of a moving car

Experimental algorithms as follows:

Step1：Converted three consecutive images $f_{k-1}(x,y)$, $f_k(x,y)$ and $f_{k+1}(x,y)$ to grayscale images $f'_{k-1}(x,y)$, $f'_k(x,y)$ and $f'_{k+1}(x,y)$;

Step2：Find the difference image by frame difference and turn difference image into binary image $D_{k,k-1}(x,y)$ and $D_{k+1,k}(x,y)$;

Step3：Make an and operations of $D_{k,k-1}(x,y)$ and $D_{k+1,k}(x,y)$, we can get image $D(x,y)$ which contains moving object;

Step4：Do morphological image processing to $D(x, y)$, we can get the moving target.

3. Conclusion

In this paper, we use a new method for moving target detection, that is improved frame difference. First of all, we detect moving target by three-frame difference, when we get the binary image, we will deal the binary image with erosion and dilation of mathematical morphology. With the different of traditional approach is that, the structure elements of each time are selected according to the actual needs of binary image. This method has no constraints on the environment where the moving target in， as a result of this, we can use this method to many place. The most prominent feature of this method has less calculation amount, higher real-time performance and higher accuracy for moving target detection. A large number of experimental results show that, the method in this paper has a strong application.

At the same time, although we can detect the most of the contour of moving target, but still have some place to be missed. To analysis the reasons, we can find two reasons. One reason is that there is little change in pixel value of moving target area, and the change just less than the threshold which is pre-set. If the reasons like this, we can consider changing the method of setting the threshold, i.e. do not use traditional method to assignment the threshold, we can consideration to assignment the threshold by statistical theory or by dynamic. The other one reason may be that variations in light intensity led to some parts of small black car were missed. These shortages need be improved, will be our next focus of the study.

References

[1] Jinman Kang, Isaac Cohen and Gerard Medioni. Tracking Objects from Multiple Stationary and Moving Cameras. England: The Institution of Electrical Engineers, 2004: 31-35.

[2] Lin Rui, Du Zhijiang and Sun Lining. Moving Object Tracking based on Mobile Robot Vision. China: International Conference on Mechatronies and Automation, 2009: 3625-3630.

[3] B. J. Lee, J. B. Park and Y. H. Joo, et al. Intelligent Kalman filter for tracking a manoeuvring target. IEE, 2004: 344-350.

[4] Yuqiang Fang, Bin Dai. An Improved Moving Target Detecting and Tracking Based On Optical Flow Technique and Kalman Filter. Proceedings of 2009 4th International Conference on Computer Science & Education, 2009: 1197-1202.

[5]Robert T. Collins, Alan J. Lipton, Takeo Kanade ,et al. A system for video surveillance and monitoring: VSAM final report[R]. The Robotics Institute, Carnegie Mellon University, Pittsburgh PA ,2000.

[6] Wei Zhang，Ping Wang. Moving Detectiong Based on Dynamic Backgroung in Video Images. Technology Square，2007，11-0028-04：127-130.

[7] Weihua He，Ping Li，Yumei Wen，Bo Ye. Algorithm of Extracting Moving Object Silhouette Based on Frame Fusion Under Complex Backguound. Computer Applications，2006，2(1):123-126.

[8]Grzegorz M. Wojcik，Wieslaw A. Kaminski. Liquid state machine built of Hodgkin-Huxley neurons and pattern recognition. Neurocomputing，2004，(58-60)：245-251.

[9]Qiulin Li，JIafeng He. Vehicles Detection Based on Three-frame-difference Method and Cross-entropy Threshold Method. Computer Engineering. 2011，37(4)：172-174.

[10] Claudio Rosito Jung. Unsupervised Multiscale Segmentation of Color Images. Pattern Recognition Letters , 2007 , 28: 523–533.

[11]Rafael C. Gonzalez, Richard E. Woods and Steven L.Eddins. Digital Image Processing Using MATLAB. Qiuqi Ruan et al. translate. Beijing: Publishing House of Electionics Industry, 2009.