An Improved Moving Object Detection Algorithm Based on Frame Difference and Edge Detection

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Abstract

Moving object detection is very important in intelligent surveillance. In this paper, an improved algorithm based on frame difference and edge detection is presented for moving object detection. First of all, it detects the edges of each two continuous frames by Canny detector and gets the difference between the two edge images. And then, it divides the edge difference image into several small blocks and decides if they are moving areas by comparing the number of non-zero pixels to a threshold. At last, it does the block-connected component labeling to get the smallest rectangle that contains the moving object. Experimental results show the improved algorithm overcomes the shortcomings of the frame difference method. It has a high recognition rate and a high detection speed, which has a broad market prospect.

1. Introduction

Moving object detection from video sequences is an important research portion, since it can be used in many regions such as intelligent video surveillance, motion analysis, human-machine interface applications, and so on. Moving object detection is the basis of moving object identification and tracking. Although a lot of studies have been conducted in recent years, the subject is still challenging [1,2,3].

Currently, the main detection algorithms include frame difference method, background subtraction method, optical flow method and statistical learning method. Optical flow method is the most complex algorithm. It spends more time than other methods, and statistical learning method needs many training samples and also has much computational complexity. These two methods are not suitable for real-time processing. Background subtraction method is extremely sensitive to the changes of light. Frame difference method is simple and easy to implement, but the results are not accurate enough, because the changes taking place in the background brightness cause misjudgment [4,5,6,7]. According to that eyes are sensitive to both of movement and edges, this paper presented an improved algorithm that is combination of frame difference and edge detection. The algorithm has improved the object segmentation and object locating. It has a small calculation and a good detection speed, so it can do real-time processing. Because the edges of moving objects are almost not changed with light, this algorithm is not sensitive to the changes of light.

This paper firstly introduces two moving object detection algorithms of fixed scenes -- frame difference method and moving edge method and analyzes their advantages and disadvantages, and then presents a new algorithm based on them, lastly gives the experimental results and analysis.

2 Typical moving object detection algorithms

2.1 Frame difference method

To detect moving object in the surveillance video captured by immobile camera, the simplest method is the frame difference method for the reason that it has great detection speed, can be implemented on hardware easily and has been used widely[5].

While detecting moving object by frame difference method, in the difference image, the unchanged part is eliminated while the changed part remains. This change is caused by movement or noise, so it calls for a binary process upon the difference image to distinguish the moving objects and noise. Further more, connected component labeling is also needed to acquire the smallest rectangle containing the moving objects.

The noise is assumed as Gaussian white noise in calculating the threshold of the binary process. According to the theory of statistics, there is hardly any pixel which has dispersion more than 3 times of

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standard deviation. Thus the threshold is calculated as following:

$$T = u \pm 3\sigma$$

While u is the mean of the difference image, σ is the standard deviation of the difference image.

The flow chart of the detecting process by frame difference method is as Figure 1.

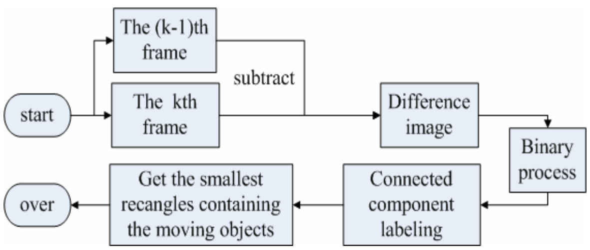

Figure 1 **The flow chart of frame difference method**

2.2 Moving edge method

Moving edge is the edge of moving objects. Difference image can be regarded as time gradient, while edge image is space gradient. Moving edge can be defined by the logic AND operation of difference image and the edge image [6].

The advantage of frame difference method is its small calculation, and the disadvantage is that it is sensitive to the noise. If the objects do not move but the brightness of the background changes, the results of frame difference methods may be not accurate enough. Since the edge has no relation with the brightness, moving edge method can overcome the disadvantage of frame difference method.

The flow chart of the detecting process by moving edge method is as Figure 2.

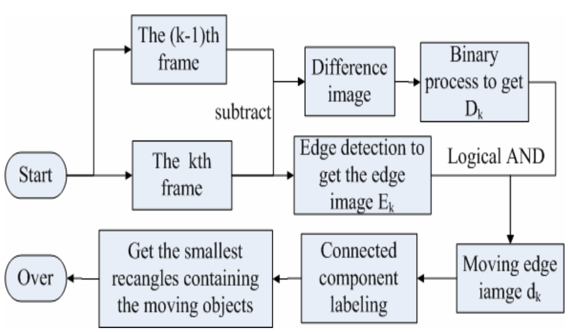

Figure 2 **The flow chart of moving edge method**

To practical images, because of the existence of noise, normally the image filtering is needed. However, the filter will generate fuzzy edge. Traditional edge detectors such as Sobel, Prewitt, and Roberts do not give the accurate edges, but the edges which have a certain width. To be precise width of a single pixel edge, we can use Canny detector. Canny detector is one of the best edge detectors, which in many areas has been widely used in image processing [6].

The basic steps of detection by using Canny detector are as follows,

(1) Filter the image by using Gaussian filter to remove the noise.

(2) Calculate the ample and direction of the gradient of each pixel of the image after filtering.

(3) Make the "non-maximal inhibition" to the gradient in order to make the edge down to one pixel width.

(4) Do double threshold processing and edge linking.

3 Improved moving object detection algorithm based on frame difference and edge detection

Moving edge method can effectively suppress the noise caused by light, but it still has some misjudgments to some other noise. This paper proposes an improved algorithm based on frame difference and edge detection. Upon analysis, the method has better noise suppression and higher detection accuracy.

3.1 Algorithm introduction

The flow chart of the detection process by using the method based on frame difference and edge detection presented in this paper is as figure 3.

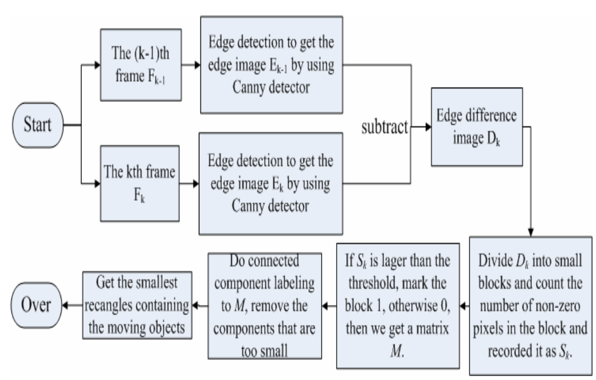

Figure 3 **The flow chart of the improved algorithm**

The steps of new algorithm presented in this paper are as follows.

(1) Get edge images $E_{k\text{-}1}$ and E_k by edge

detection with two continuous frames F_{k-1} and F_k by using Canny edge detector.

(2) Get edge difference image D_k by difference between E_k and E_{k-1}.

(3) Divide edge difference image D_k into some certain small blocks and count the number of non-zero pixels in the block, and recorded it as S_k.

(4) If S_k is lager than the threshold, mark the block is a moving area, otherwise it is a static area. Let 1 presents moving area and 0 presents static area, we can get a matrix M.

(5) Do connected components labeling to M, and remove the connected components that are too small.

(6) Get the smallest rectangles containing the moving objects.

The algorithm has improved both the object segmentation and object locationing. Following is a brief analysis.

3.2 Object segmentation

Object segmentation is to divide the image into moving area and static area. The algorithm presented in this paper will get the edge images first, then difference them to get the edge difference image. In the final image we get, the pixel value of background area equal to 0 and pixel value of the edge of moving objects equal to 1. Now we will compare the difference between our algorithm and moving edge method mentioned in 2.2.

(1) In moving edge method, assume two continuous frames are F_{k-1} and F_k, background is B, moving objects are M_{k-1} and M_k, and independent white noise is N_{k-1} and N_k for two frames each. Then we can have

$$F_{k-1} = B + M_{k-1} + N_{k-1}$$

$$F_k = B + M_k + N_k$$

So we can get the difference between two frames:

$$D_k = F_k - F_{k-1} = M_k - M_{k-1} + N_k - N_{k-1}$$

Use Canny edge detection with frames F_k. We can get edge image E_k. Then we can get the result:

$$R_k = D_k E_k = E_{M_k} + E_{N_k}$$

E_{Mk}, E_{Nk} are edge images caused by M_k and N_k each.

Define signal noise ratio is

$$SNR = \frac{S_{E_M}}{S_{E_N}}$$

While S_{EM} is the number of edges caused by moving objects, and S_{EN} is the number of edges caused by noise.

Then we know the SNR of the moving edge method is

$$SNR_1 = \frac{S_{EMk}}{S_{ENk}}$$

(2) In our method, we first get edge images by Canny edge detector:

$$E_{k-1} = E_B + E_{M_{k-1}} + E_{N_{k-1}}$$

$$E_k = E_B + E_{M_k} + E_{N_k}$$

Then by difference we get

$$R_k = E_{M_k} - E_{M_{k-1}} + E_{N_k} - E_{N_{k-1}}$$

Since in the practical system, the difference between two edge images is absolute value of the difference value and the edges of two images are not the same when the objects are moving.

$$E_{M_{k-1}} \neq E_{M_k}$$

So actually in the edge difference image we can have the sum of the edges of two frames.

$$R_k = E_{M_k} + E_{M_{k-1}} + E_{N_k} - E_{N_{k-1}} = 2E_{M_k} + E_{N_k} - E_{N_{k-1}}$$

Because the noise is independent and two frames are dependent with each other, we can have

$$E_{N_k} - E_{N_{k-1}} < 2E_{N_k}$$

The SNR in our algorithm is

$$SNR_2 = \frac{E_{M_k} + E_{M_{k-1}}}{E_{N_k} - E_{N_{k-1}}} > \frac{2E_{M_k}}{2E_{N_k}} = SNR_1$$

It shows that the SNR in our algorithm is less than the moving edge method. Our method will work more efficiently.

3.3 Object locationing

After separating moving objects and background, we need to locate the object so as to get the exact position of moving objects. The common approach is to calculate connected components in binary images, delete those connected components whose area are so small, and get circum-rectangle of the object.

One of the most familiar connected components algorithms is a pixel labeled algorithm based on eight conjoint areas. According to this approach, zero is assigned to each pixel of background and an only number we called tab is assigned to every connected component while the biggest tab represents the number of connected components in the image. Basic steps of this algorithm are as follows:

Travel the entire image R from top to bottom and from left to right while a non-zero value v is assigned to each non-zero pixel $R(i, j)$. The value v is selected according to the tab of conjoint areas.

- If all the conjoint areas are part of the background which means the value of the pixels of all these areas are zero, a new tab which is never used will be assigned to $R(i, j)$.

- If there is only one conjoint area has a non-zero tab, this tab will be assigned to $R(i, j)$.
- If there are more than one conjoint areas whose tab are not zero and some of these tabs are different, the smallest one among these tabs will be assigned to $R(i, j)$ while all the other pixels whose tab is same as one of the rest of these tabs will be changed to the smallest one as well.

As we can see from the steps mentioned above, the time complexity of connected components labeling is $O(MN)$, while M and N represent the height and width of the image. Our approach divides the entire image into separate blocks during object locating before connected components labeling so as to diminish the amount of operation evidently. If the size of original image is 640×480 and we divide the image into 16×16 small blocks to be operated, the time of operation can be diminished to 1/1200 of the original one. It improves the speed of detection greatly, and the result of the latter experiment validates this conclusion as well.

4 Experimental results and analysis

In this paper, an improved moving object detection algorithm based on frame difference and edge detection is brought forward. It was simulated on the PC with Pentium 4 CPU and 2.50GHz 256 EMS memory. The operating environment is Windows XP. Programming environment is Matlab 7.0. Size of the sequence image is 640×480. Partial stimulation results are as follows.

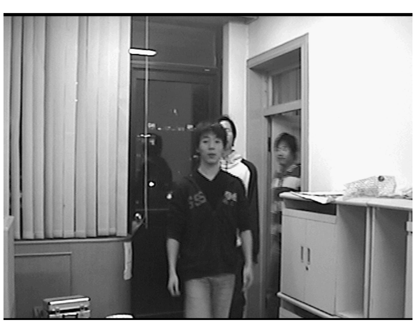

Figure 4 **Three continuous frames**

Figure 5 **Detection results by using the improved algorithm**

This paper also achieves several classical algorithms (frame difference method [5], moving edge method [6], background subtraction method [7]), and compared their performance with our improved algorithm by detecting moving object from the video sequences captured in the laboratory which has 250 frames and 625 moving objects totally. The analysis results are shown in the following table.

Table1 **Performance analysis of four moving object detection algorithm**

	Detecting time/seconds	Recognition rate	False
Frame difference	38.08	92.9%	8
Moving edge	46.12	96.3%	21
Background subtraction	90.34	98.4%	0
Our improved algorithm	1.873	99.2%	3

From the results we can see that the improved moving object detection algorithm based on frame difference and edge detection has much greater recognition rate and higher detection speed than several classical algorithms. This algorithm will appear individual false under more complicated background. There is still room for improvement.

5 Conclusion

This paper presents an improved moving object detection algorithm based on frame difference and edge detection. This method not only retains the small calculation from frame difference method and the impregnability of light from edge detection method, but also improves in noise restraining. Meanwhile, it divides the image to small blocks to do connected component labeling, significantly speeding up the detection. Experimental results show that the algorithm has great recognition rate, high speed, and will be a good candidate for practical systems.

Reference

[1] Wan Ying, Han Yi, and Lu Hanqing, "The Methods for Moving Object Detection". Computer Simulation, Oct 2006, pp. 221-226.

[2] Qiu Shangbin, Li Gang, and Lin Ling, "New Method of Motion Detection and Background Updating". Journal of Liaoning Institute of Technology, Feb 2005, pp. 10-12.

[3] Dai Kexue, Li Guohui, Tu Dan, and Yuan Jian, "Prospects and Current Studies on Background Subtraction Techniques for Moving Objects Detection from Surveillance Video". Journal of Image and Graphics, July 2006, pp. 919-927.

[4] Wang Junqing, Shi Zelin, and Huang Shabai, "Detection of Moving Targets in Video Sequences". Opto-Electronic Engineering, Dec 2005, pp. 5-8.

[5] Ren Mingwu, and Sun Han, "A Practical Method for Moving Target Detection Under Complex Background". Computer Engineering, Oct 2005, pp. 33-34.

[6] Milan Sonka, Vaclav Hlavac, and Roger Boyle, "Image Processing, Analysis, and Machine Vision (Second Edition)", Posts & Telecom Press, Beijing, Sep 2003.

[7] Zhang Yunchu, Liang Zize, Li En, and Tan Min, "A Background Reconstruction Algorithm Based on C-means Clustering for Video Surveillance", Computer Engineering and Application, 2006, pp. 45-47.

[8] Jia Zhentang, Li Shengping, He Guiming, and Tian Hui, "A Video Object Segment Algorithm Based on Moving Edge Detection". Journal of Computer Research and Development, May 2003, pp. 684-689.

[9] Rafael C. Gonzalez, and Richard E. Woods, "Digital Image Processing (Second Edition)", Publishing House of Electronics Industry, Beijing, Mar 2005.

[10] Yu Chengzhong, Zhu Jun, and Yuan Xiaohui, "Video Object Detection Based on Background Subtraction". Journal of Southeast University(Natural Science Edition), Nov 2005, pp. 159-161.

[11] Li Quanfu, Dong Huiying, and Zhao Quanbang, "Moving Objects Detection Based on Background Subtraction and Frame-Difference of Block Coding". Transaction of ShenYang LiGong University, Aug 2006, pp. 32-35.

[12] Cao Li, Wang Yaming, Zhou Weida, and Huang Wenqing, "Moving Object Detecting and Tracking Based on Statistical Background Model and Filter Estimation". Computer Simulation, May 2006, pp. 194-196.

[13] Shi Lina, Tu Feng, and Zhu Hong, "A Method for the Detection of Moving Targets in Complex Background". Electronic Engineer, Jan 2006, pp. 45-47.

[14] Xiao Mei, Han Chongzhao, and Zhang Lei, "Moving Object Detection Algorithm Based on Space-Time Background Difference". Journal of Computer-Aided Design and Computer Graphics, July 2006, pp. 1044-1048.

[15] Zhu Minghan, and Luo Dayong, "Moving Objects Detection and Tracking Based on Two Consecutive Frames Subtraction Background Model". Computer Measurement and Control, 2006, pp. 1004-1006.

[16] Fan Yihong, Zhang Yuan, and Huang Tao, "New Algorithm for Detection of high-speed Moving Objects Using Video Monitor Method". Computer Engineering, Nov 2006, pp. 240-242.