A Moving Target Detection Algorithm Based on the Dynamic Background

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***Abstract*— Advantages and disadvantages of two common algorithms frequently used in the moving target detection: background subtraction method and frame difference method are analyzed and compared in this paper. Then based on the background subtraction method, a moving target detection algorithm is proposed. The background image used to process the next frame image is generated through superposition of the current frame image and the current background image with a certain probability. This algorithm makes the objects which stay long time to be a part of the background after a certain period of time, but not be detected as a part of foreground. The experimental results show that this algorithm can detect moving targets more effectively and precisely.**

Keywords-background subtraction; frame difference; moving target detection; dynamic background

I. INTRODUCTION

Intelligent video surveillance is a new research direction in the field of computer vision. It uses the method of computer vision and detects the movement target in the monitoring scene by automatic analysis the image sequence by the camera recording. And the research on moving target detection and extraction algorithm can be said to be key issues in intelligent video. Its purpose is the detection and extraction of the moving targets from the scene of the video image sequence. Therefore the effective detection of moving targets determines the system performance. Therefore, this article focuses on key technology in the moving targets detection and extraction.

In this paper, firstly, it has a brief introduction of pre-treatment of the video images. It reduces the error in the image processing after. Secondly the paper focuses on analysis comparison the two algorithms: the background subtraction and the frame difference. Lastly, this paper selects based on the background subtraction method to improve it and present a moving target detection algorithm based on the background which has dynamic changes.

II. IMAGE PREPROCESSING

A. Noise

Noise is any entity which is not of benefit to the purpose of image processing. The influence of noises on the image signal amplitude and phase is complexity. So how to smooth out noise and keep the details of image is the major tasks of the image filtering.

B. Noise Filter

We use the median filter in this paper. Median filter is a non-linear method for removing noise. Its basic idea is to use the median of the neighborhood pixel gray value instead of the gray value of pixel point. For the odd elements, the median refers to the size of the middle value after sorting; For even-numbered elements, the median refers to the average size of the two middle values after sorting [1]. Median filter as a result of this method is not dependent on the neighborhood with a lot of difference between typical values, which can remove impulse noise, salt and pepper noise at the same time retain the image edge details. In general the use of a median filters contain odd-numbered points of the sliding window. Specific methods is determining a first odd-numbered pixel window W. Each pixels in window line by the size of the gray value，and use the location of the gray value between the image $f(x,y)$ gray value as a substitute for enhanced images $g(x,y)$,as follows:

$$g(x,y) = Med\{f(x-k, y-l), (k,l) \in W\} \tag{1}$$

W is the window size which is selected.

III. IMAGE SEGMENTATION

In the Images research and application, Images are often only interested in certain parts. These parts are often referred to as goals or foreground (as other parts of the background). In order to identify and analyze the target in the image, we need to isolate them from the image. The Image segmentation refers to the image is divided into regions, each with characteristics and to extract the target of interest in processes [2].

The image segmentation used in this paper is threshold segmentation. To put it simply, the threshold of the gray-scale image segmentation is to identify a range in the image of the gray-scale threshold, and then all image pixels gray values are compared with the threshold and according to the results to the corresponding pixel is divided into two categories: the foreground of, or background. The simplest case, the image after the single-threshold segmentation can be defined as:

$$g(x,y) = \begin{cases} 1 & f(x,y) > T \\ 0 & f(x,y) \le T \end{cases} \tag{2}$$

Threshold segmentation has two main steps:

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l) Determine the threshold *T*.

2) Pixel value will be compared with the threshold value *T*.

In the above steps to determine the threshold value is the most critical step in partition. In the threshold selection, there is a best threshold based on different goals of image segmentation. If we can determine an appropriate threshold, we can correct the image for segmentation.

IV. ANALYSIS AND COMPARISON OF THE TWO TYPES OF MOTION DETECTION ALGORITHM

Intelligent visual surveillance system can be used many different methods for detection of moving targets, A typical method such as background subtraction method, frame difference method. These methods have advantages and disadvantages, the following will be introduced.

A. Background subtraction method

Background subtraction method is a technique using the difference between the current image and background image to detect moving targets. Process flow chart is shown as Fig. 1.

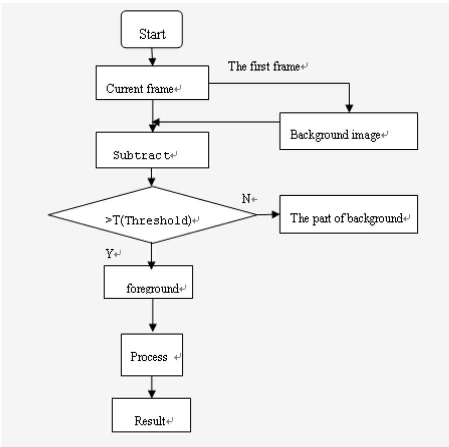

Figure 1. Flow chart of background subtraction method

The basic idea is the first frame image stored as background image. Then the current frame image f_k with the pre-stored background image B subtraction, And if the pixel difference is greater than the certain threshold, then it determines that the pixel to pixel on the moving target, or as the background pixel. The choice of threshold of the background subtraction to achieve the success of motion detection is very important. the threshold value is too small will produce a lot of false change points, the threshold choice is too large will reduce the scope of changes in movement. The appropriate threshold request be adapt with the impact which be had by scenes and camera on the wavelength of the color, the changes of light conditions, so the choice of the dynamic threshold should be selected [3]. The method formula is shown as (3) and (4).

$$R_k(x,y) = f_k(x,y) - B\ (x,y) \quad (3)$$

$$Dst_k(x,y) = \begin{cases} 1, \text{background} & R_k(x,y) > T \\ 0, \text{target} & R_k(x,y) \le T \end{cases} \quad (4)$$

Background subtraction is used in case of the fixed cameras to motion detection. Its advantage is easy to implement, fast, effective detection, can provide the complete feature data of the target. The shortcomings are frequent in moves of the occasions may be difficult to obtain the background image. Immovable background difference is particularly sensitive for the changes in dynamic scenes, such as indoor lighting gradually change.

The following is the video screenshot of the background subtraction method to achieve , as Fig. 2 – Fig. 5 shows

Figure 2. Background image

Figure 3. Current frame image

Figure 4. Contour map after subtraction

Figure 5. Target image

From the images we can see that a car that does not belong to the moving target appeared in the upper right corner of the target figure. This is due to the fixed background subtraction method does not process the dynamic changes in background. This is an important drawback of the method.

B. Frame Difference Method

Frame difference method, is also known as the adjacent frame difference method, the image sequence difference method etc. It refers to a very small time intervals Δt (Δt <<1s) of the two images before and after the pixel based on the time difference, and then thresholding to extract the image region of the movement, according to which changes in the region to distinguish background and moving object [4]. Frame difference of the specific flow chart as shown in Fig. 6.

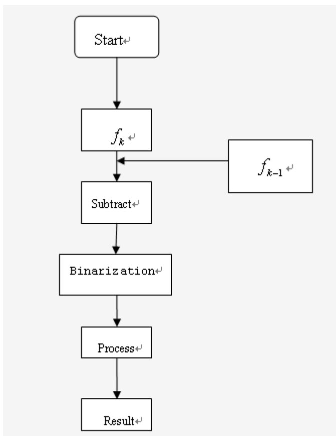

Figure 6. Flow chart of frame difference method

The specific method on calculation of difference image Dst_k between the kth frame images f_k with the (k-1)th frame image f_{k-1} is differential, the negative differential and fully differential, the corresponding formula is as follows:

$$\text{Differential:} \quad Dst_k = \begin{cases} f_k - f_{k-1}, if(f_k - f_{k-1}) > 0 \\ 0, else \end{cases} \tag{5}$$

$$\text{Negative Differential:} \quad Dst_k = \begin{cases} |f_k - f_{k-1}|, if(f_k - f_{k-1}) < 0 \\ 0, else \end{cases} \tag{6}$$

$$\text{Fully Differential:} \quad Dst_k = |f_k - f_{k-1}| \tag{7}$$

The binarization for the differential image can get a collection of pixel movement. The following are the video shots of frame difference method, as Fig. 7 – Fig. 9 shows.

Figure7. Current frame image

Figure 8. Contour map after differential

Figure 9. Target image

From the above screenshot we can see that the advantages of frame difference method is the computation of small, fast, simple, low complexity of program design. It is only sensitive to the movement of objects. In fact, only detect relative motion of the object. Because there is a very short time interval between the two images, and the impact of the differential image by changes in light is small. So it is very suitable for dynamic changes in the scene [5]. Its drawback is that can not be completely extracted features of all relevant objects pixel point, unless the moving object itself has more complex texture features; After differential the interior of movement entities is easily empty; the non-zero area shown is generally the continuous or intermittent stripe-shaped region which is closely related with the edge of moving objects, as shown in Fig. 9. This region is more large than the region of the actual objects, its external rectangular were stretching on direction of the movement; it is very sensitive to noise and do not detect the accurate location of objects. Relative to the velocity of target, the video system sampling quickly (Δt is very small), its objectives in the location of two adjacent frames will be a very small difference. The location of the mid-point in the frame can be used as the approximate target location. If the speed of moving target detection compared with the sampling rate is very fast, this method will be improved.

V. MOVING TARGET DETECTION ALGORITHM BASED ON THE DYNAMIC BACKGROUND

Through the comparison of two moving target detection algorithms in the above section, in this paper it present a moving target detection algorithm based on the dynamic background.

A. The dynamic update of the background

In the background subtraction method, we can consider that the whole scene from two parts: the background, the foreground. Background is a static scene and which can be seen; Foreground is the moving objects which are interested in the video surveillance, such as: vehicles, pedestrians, etc [6]. However, due to the scene of the monitor changes over time, the foreground stagnation in the picture for a long time should be re-classified as part of the background; and objects which is belong to the background should be classified as part of the foreground when it starts moving. Background pixel that changes and updates over time, It is the basis of background subtraction method. In this paper, background is updated over time to re-construct the background images. The flow chart is shown in Fig.10.

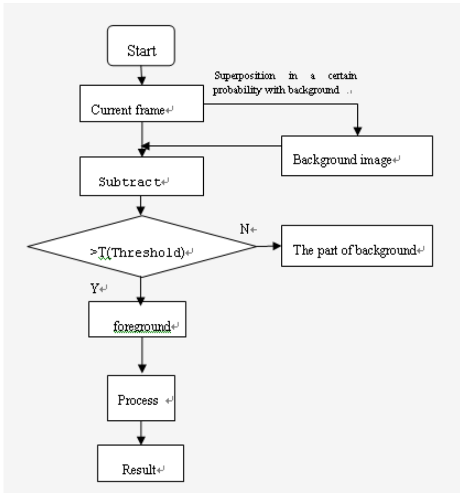

Figure10. Flow chart of moving target detection algorithm based on dynamic background

The formula of the moving target detection algorithm based on the dynamic background as follows:

$$B_k(x,y) = B_{k-1}(x,y), f_{k-1}(x,y) \text{superposition in a certain probability} \tag{8}$$

$$R_k(x,y) = \left| f_k(x,y) - B_{k-1}(x,y) \right| \tag{9}$$

$$Dst_k(x,y) = \begin{cases} 1, \text{background} \quad R_k > T \\ 0, \text{target} \quad R_k \le T \end{cases} \tag{10}$$

B_k is the background of the *kth* frame image. f_k is the *kth* frame image. The pixel in the image B_k is generated from the pixel in the image f_{k-1} superposition in a certain degree of probability with the pixel in the background image B_{k-1}. With time, the stagnation moving targets of the video again and again as a result of superimposed to the background, in the end it can be a part into the background. And the opposite the movement part of the background eventually separated from the background to become foreground. In this paper, the function *GetBackground* used to achieve background image with the current frame superposition outputting. Following introduce the used of the function *GetBackground* :

The definition of function: *GetBackground(Image* background, const Image* src_image, double alpha)*;

Introduce of the parameters： the input image: *src_image*, background image: *background*, The weight of the input image: *alpha*.

Function: Calculation of the input image *src_image* and the background image *background* weighted sum，and makes the image *background* as an average cumulative sum of the frame sequence。 The specific formula is as follows:

$$background(x, y) = (1-\alpha)background(x, y) + \alpha \cdot src\_image(x, y) \tag{11}$$

And α (*alpha*) regulates the update rate (how quickly the image background in order to forget the front of the frame).

The following is the screenshots of the background image at the different time used by the new algorithm:

Figure 11. Background at start time

Figure 12. After a period of time

We can see after a period of time the car at upper into the background, and the car at the right upper out of the background.

B. *Determination of threshold*

In order to increase the adjustability of the threshold and the robustness of the background image on the brightness changes slowly. The determination of threshold as follows:

$$\theta = \left\{ mid(\theta_1, \theta_2, \theta_3, \theta_4), \theta_i = \frac{1}{N_{M_i}} \left(c \cdot \sum_{(x,y)\in M_i} R(x, y) \right) \right\} \tag{12}$$

And *c* determined by the experiment, the general admission 3-5; *Mi* is a region of the background, and generally selects the area at the edge; *N* is the area of *Mi.* The algorithm selected the four corners of differential gray image region to be calculated respectively，and makes the mid-value as the final check of the threshold value, and get a better result.

C. *Extraction of detailed images of moving targets*

This requires the adoption of connectedness analysis to extract the complete moving target. There are two type of connectedness: four-connected and eight-connected, as shown as Fig. 13 and Fig. 14.

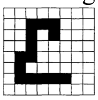

Figure 13. Four-connected

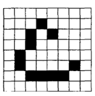

Figure 14. Eight-connected

Some concepts of connectedness:

- Foreground and Background: The set of all pixels which value is 1 of the image named foreground. And others are named the background.
- Definition of the connectedness: In the binary image, the known pixel *p*, *q* is 1, if there is a path from *p* to *q*, and the all the pixels of the path are 1, then *p* and *q* are connected.

From the definition of connectedness, we can see the foreground and the background should be using a different connectedness.

Marked connectedness algorithm: Recursive marking algorithm. a) Scan image, to find a no marked pixel that its value is 1, and marks it a new distribution L; b) recursive allocate the mark L to its neighbor; c) If there is no point not marked, then stop; d) return step a) [7].

Following is the images which have been marked connectedness, as Fig.15 and Fig.16 shown.

Figure 15. Source image

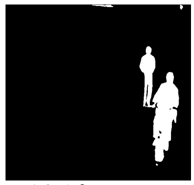

Figure 16. After connectedness and internal be filled

The approach taken is make the result of connectedness and segmentation with the grayscale image of source image do the "and" operation. The formula is as follows:

$$Dst_k(x, y) = \begin{cases} f_k(x, y), if(Dst_k(x, y)) = 0 \\ Dst_k(x, y), else \end{cases} \tag{13}$$

Screenshots are as follows:

Figure 17. Grayscale image

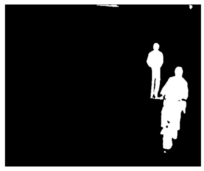

Figure 18. After connectedness and internal be filled

Figure 19. Detailed images of moving targets

VI. PERFORMANCE COMPARISON OF THE THREE METHODS' RESULT

Through the analysis of section 3 and 4, we knew that the three methods have some advantages and disadvantages. We'll compare them in recognition accuracy and speed performance.

A. *The comparison of recognition accuracy*

1) Background subtraction method: This method is able to recognize moving objects, and the detected object contour is clear, the extracted object image is complete. But the disadvantage is that when the moving object stop in the scene this method can not put it into the background automatically. Fig. 20 and Fig.21 show the original image and the detected moving object when the car moved into the scene at time *t1* and then stop. Fig.22 and Fig.23 show the original image and detected object image at time *t2*.

Figure 20. Source image at *t*1

Figure 21. Result image at *t*1

Figure 22. Source image at *t*2

Figure 23. Result image at *t*2

We can find out that from *t1* to *t2*, the car did not move, but this method detected it as moving object.

2) Frame Difference: this method is able to recognize moving object. But the detected object's contour is dim and the extracted object image is not complete. The change of background has little influence over the result image, and we can always detect out the right moving object. Fig.24 and Fig.25 show the detected object image at time *t1* and *t2*

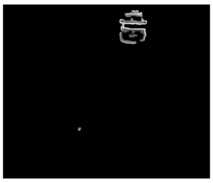

Figure 24. Result image at *t*1

Figure 25. Result image at *t*2

We can find out that it recognizes the right object. But the object's silhouette is not clear and there are holes inside it

3) The moving target detection algorithm based on the dynamic background: it is able to recognize moving target, and the detected object contour is clear, the extracted object image is complete. When the moving object stop in the scene this method can put it into the background automatically. Fig. 26 and Fig. 27 also show the detected object image at time *t1* and *t2*. We can find out that from *t1* to *t2*, the method recognize the right moving object and extracted the clear image of target.

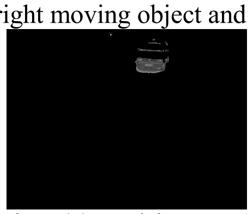

Figure 26. Result image at *t*1

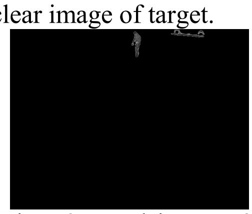

Figure 27. Result image at *t*2

B. The comparison of operating efficiency

We used the three algorithms to detect the same video, and compared them in three aspects: running time (100 frames), memory, smooth output the result. The results as shown in TABLE I, we can find that although the new algorithm is a little larger than other two algorithms, however its output is also smoothly and the memory isn't too much, so it meets the requirements of real-time.

TABLE I. THE COMPARISON OF OPERATING EFFICIENCY

Name	Running Time(s/100frame)	Memory (KB)	Smoothly
Background Subtraction	3.772	27292	Yes
Frame Difference	3.891	21732	Yes
The Moving Target Detection Algorithm Based on the Dynamic Background	5.109	28209	Yes

VII. CONCLUSION

Although the moving target detection algorithm based on the dynamic background can better meet the set performance requirements. However, to design a perfect intelligent visual surveillance system, we should further improve the system robustness and increase target identification functions.

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