Moving Object Detection and Tracking Algorithm

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Abstract
Moving object detection and tracking play an important role in the intelligent video surveillance system. The traditional moving object detection algorithm seems sensitive to light and shows poor anti-interference performance. Therefore, a new method is proposed combining the inter-frame difference method with improved background subtraction method which makes use of color and texture information and dual-threshold is used to detect moving targets and makes multiple judgments. In addition, Meanshift and Kalman filtering algorithm are used to track the moving object, fast moving objects can be tracked acutely with this method. The experiments show that the algorithm proposed is adopted to detect and the moving target accurately and can resist interferences brought about by the slow slight movements in the scene with better robustness.

Keywords: Moving Target Detection; Tracking; Background Subtraction; Inter-frame Difference; Meanshift and Kalman filtering

1. Introduction

Moving target detection and tracking are important parts in intelligent video surveillance system. Obtaining the dynamic information of the target accurately is significant to the subsequent target identification, tracking, behavior understanding and descriptions [1]. Moving target detection is to detect moving objects from the changing background images in continuous video images. Moving target tracking is to find various locations of the moving object in the video sequences. The common used moving target detection algorithms include background subtraction, the frame difference method and optical flow method [2]. In addition, there are also some methods in moving target detection such as space-time model, human behavior analysis, hybrid graph method, wavelet transformation and feature weight [3-6]. But the accuracy of moving target detection is still a difficult problem to be solved [7]. Therefore, a new method is proposed combining the inter-frame difference method with improved background subtraction method which makes use of LBP algorithm combing with texture and color information to build the background model. Two parameters and dual-threshold are set to detect moving targets. It not only uses the change of pixel gray value, but also uses the number of changed pixels to detect moving targets. In addition, morphological filtering and connectivity analysis are also used in this paper. What's more, Meanshift algorithm and Kalman filtering are used to track moving objects. The experiments show that the algorithm proposed can detect and track the moving target accurately.

2. Moving Object Detection Algorithm

The common used moving target detection algorithms are background subtraction method, inter-frame subtraction method, optical flow method. Optical flow method makes use of the instantaneous velocity which is generated in the continuous movements of the pixels in the moving object. In the case of unknown scene information, the method can detect the moving objects. Optical flow algorithm has poor anti-noise performance, the calculation is quite complicated, and the hardware requirements are also very high, so it is not suitable for real time processing [8-15]. Relatively speaking, background subtraction method and inter-frame subtraction method are simple and easy to implement [16].

2.1. Inter-frame Subtraction Method

Two or more adjacent frames are used to do differential to detect moving target in inter-frame subtraction method. The detected moving target is usually within the minute cavities and has poor connectivity with this method. But this method has strong adaptability to the environment, to some extent; it can resist the interference of light.

The video sequence during a certain period of time is collected, $f_k(x, y)$ represents the current frame, and $f_{k-1}(x, y)$ and $f_{k+1}(x, y)$ represent its adjacent two frames,

$$D_{(k,k-1)}(x, y) = f_k(x, y) - f_{k-1}(x, y) \tag{1}$$

$$D_{(k,k-1)}(x, y) = \begin{cases} 1 & D_{(k,k-1)}(x, y) \geq T_1 \\ 0 & else \end{cases} \tag{2}$$

$$D_{(k,k+1)}(x, y) = f_{k+1}(x, y) - f_k(x, y) \tag{3}$$

$$D_{(k,k+1)}(x, y) = \begin{cases} 1 & D_{(k,k+1)}(x, y) \geq T_1 \\ 0 & else \end{cases} \tag{4}$$

Where T_1 is the threshold value. $D_{(k,k-1)}(x, y)$ is the region which is obtained by the current frame $f_k(x, y)$ and the previous frame $f_{k-1}(x, y)$ to do differential. $D_{(k,k+1)}(x, y)$ is the region which is obtained by the current frame $f_k(x, y)$ and the subsequent frame $f_{k+1}(x, y)$ to do differential.

There are three common used frame difference methods: direct difference method, the symmetrical difference method and the accumulated frame difference method. Direct difference method makes use of two adjacent frames directly to do differential to detect moving target. The method is simple, but the detected moving target is not accurate enough. Symmetric difference method makes use of three images to do differential and the detected moving target is the integration of the results. Cumulative multi-frame difference method makes use of more than three images to do differential and the detected moving target is the integration of the results. The method is relatively complex. Therefore, three consecutive images are used in this paper to do inter-frame subtraction.

The following figure 1 is the detection result of moving target which makes use of three images to do differential.
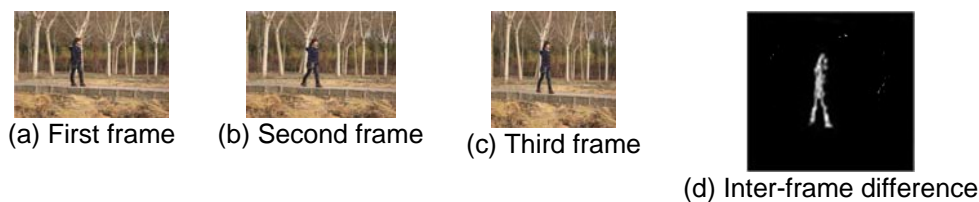
(a) First frame   (b) Second frame   (c) Third frame   (d) Inter-frame difference

Figure 1. Inter frame differential detection

2.2. Background Difference Method

The key step of background subtraction is background modeling and background updating. The basic idea of the background difference method is to do differential between current image and background image, and then according to the threshold to judge whether it belongs to the moving target or not. When the color between moving target and the background is not very close, the complete moving target can be detected. But this method is very sensitive to changes in light and environment.

The video sequence is collected during a certain period of time. $f_k(x,y)$ represents the current frame, and $B_k(x,y)$ represents the background image which is obtained by the training. $D_k(x,y)$ represents the background difference image.

$$D_k(x,y) = f_k(x,y) - B_k(x,y)$$

(5)

$$D_k(x,y) = \begin{cases} 1 & D_k(x,y) \geq T_2 \\ 0 & else \end{cases}$$

(6)

T_2 is the threshold which is set in advance, and according to the threshold to judge whether it belongs to the moving target or not. Background subtraction method is sensitive to light and shadow, combing with LBP algorithm and the texture and chrominance information into the background modeling. Because the texture and chrominance information is insensitive to shadow, so it can effectively detect the moving target. In the following Figure 2, (a) is the established background model of the captured video sequence using LBP algorithm, (b) is the basic LBP texture histogram and(c) is the LBP uniform pattern histogram.
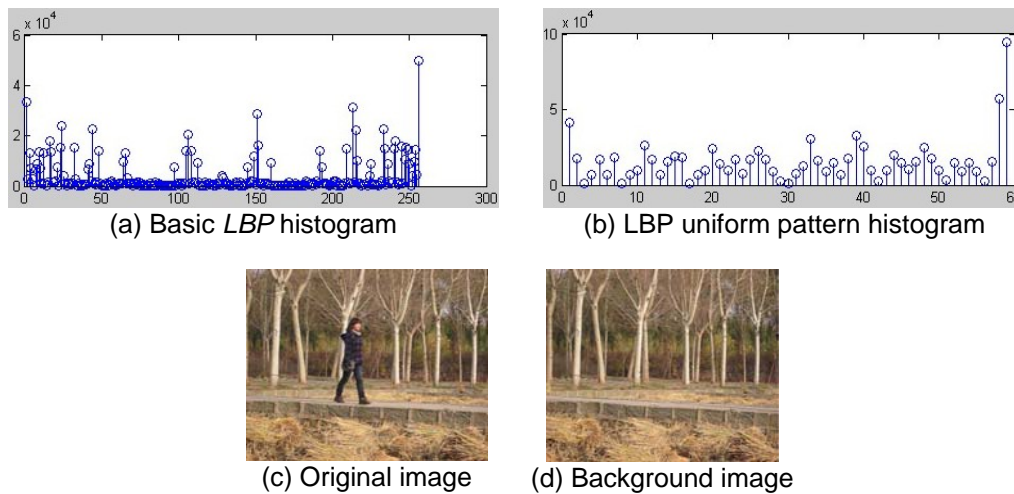

(a) Basic *LBP* histogram   (b) LBP uniform pattern histogram

(c) Original image   (d) Background image

Figure 2. Background modeling

3. Improved Moving Object Detection Algorithm

There are many problems caused by using the gray-scale variation of the pixel and single threshold to detect the moving target such as false detection. Accounted for the proportion of the moving target in the whole image, another threshold and two parameters, X and Y are set in this paper. Three frames and LBP operator are used, combing with inter-frame difference method and background subtraction method. During the moving object detection process, according to the range of variation of the pixel gray, the first threshold value is set. For the proportion of the moving target in the whole image, the second threshold value is set. With background subtraction method, a parameter X is set, if the two threshold values are met, X =1, otherwise, X =0. With inter-frame difference method, a parameter Y is set, if the two threshold values are met, Y =1, otherwise, Y =0. The algorithm is used not only to satisfy environment changes, but also to detect the moving target we are interested in accurately. The algorithm makes use of the collected three frames $f_{k-1}(x,y)$, $f_k(x,y)$, $f_{k+1}(x,y)$ from the video sequence and one of the obtained background images $B_k(x,y)$. The entire testing process is shown as follows.

(1) The first frame video image and the background image are subtracted, and then decision is made whether satisfied with the threshold value of the background difference. If the threshold value matches the threshold value of the background difference, judgment is further made whether the number of detected pixels is within the range of the number of interested pixels. If the two threshold values are met, X =1, otherwise, X =0.

(2) If X =0, there is no need to go on further judgment. It means that there is no moving object in this frame. If X =1, it may be the changes in the external environment. Then, further judgment is needed in the second frame.

(3) For the second frame, the above judgment process is repeated. If X =0, that is to say, relative to the first frame, the second frame changes a lot. Thereby we can determine the pixel change of the first frame is not caused by the environmental changes, but there is a moving target enters in the first frame. If X =1, further judgment is needed.

(4) The first frame and the second frame are subtracted, and then decision is made whether satisfied with the threshold value of the inter-frame difference. If the threshold value matches the threshold value of the inter-frame difference, further to determine whether the number of detected pixels are within the threshold range of the number of interested pixels. If the two threshold values are met, Y =1, otherwise, Y =0.

(5) If Y =1, there are some changes of the former two frames in both background difference and inter-frame difference. If Y =0, the changes of the former two frames may be caused by the environmental changes. Further judgment is needed in the third frame.

(6) The third frame and the background image are subtracted. If X =0, there is moving object in the former two frames. If X =1, then the judgment of the inter-frame difference is needed. Third frame and the second frame are subtracted. If Y =1, it indicates that there are moving targets in these three frames. If Y =0, it suggests that these three frames are affected by light changes, then the background should be updated.

4. Detection Results and Analysis

The video sequence is collected in static background, regarding people as the moving object in the video sequence. Compared with inter-frame difference and background difference methods, the experimental results are shown in Figure 3.

(a) Original image   (b) Grayscale image

(c) Inter frame difference   (d) Background subtraction
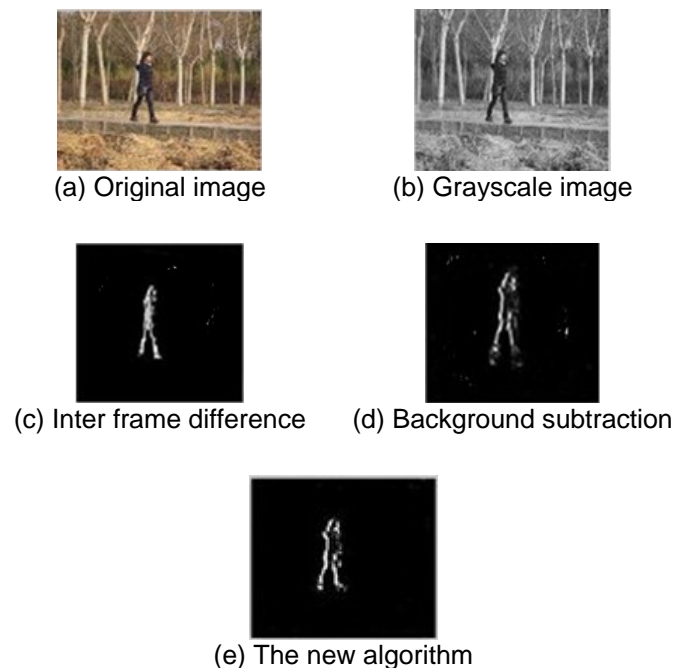
(e) The new algorithm

Figure 3. Experimental results Comparison Chart

In Figure 3, (a) represents the original image. (b) represents the transformed gray image. (c) represents the moving target which uses inter- frame difference method. From the Figure 7, frame difference method used results in strong adaptability to the environment, but the moving target detected usually has slight interference. In addition, in the moving area, changing region is often detected falsely. Due to the interference of the external environment, the moving target detected will normally be greater than the actual target, so it can not be a true reflection of the actual shape. When gray values of moving target are similar in a wide range, it will produce many small holes. This would also lead to the breakage or chipping of the edge in the extracted moving target. It is also not conducive to subsequent processing.

(d) represents the moving target which uses background subtraction method. From the Figure 7, relatively complete outline of the moving target can be extracted with this method. However, it's very sensitive to changes of light, weather and other external conditions. The interference of the moving target detected is relatively high compared to the inter-frame difference method.

(e) represents the moving target which uses the new proposed algorithm. It has strong adaptability to the environment and can overcome the limitations of background subtraction method and frame difference method. It is insensitive to external interferences, such as light, weather, the swing of branches and so on. The method has less interference and can extract more complete and clear moving target through the multiple judgments.

5. Tracking Results and Analysis

In computer vision, there are many methods in target tracking, MeanShift algorithm is used widely, and it is a nonparametric density estimator which iteratively computes the nearest mode of a sample distribution, which can guarantee the accuracy of tracking in most situations. But when the target is totally occluded by obstacles, MeanShift algorithm mistakes obstacles for a possible target model. If the moving target appears again in subsequent frames, it will not be effective, the following Figure 4 is the experiment result.
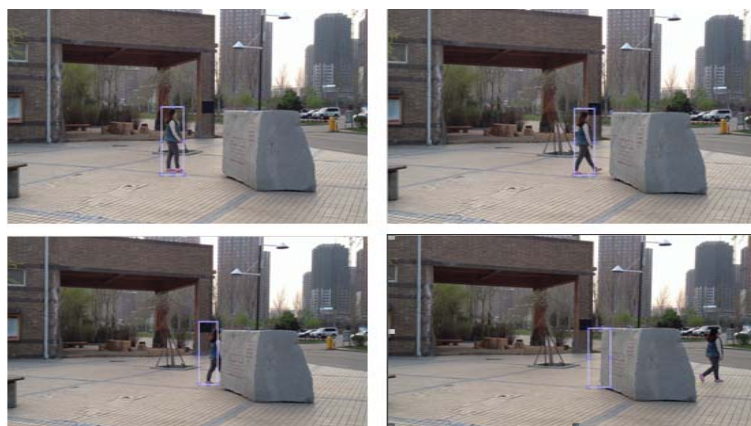

Figure 4. The tracking results of traditional meanshift algorithm

In order to solve this problem, the new tracking method which combines kalman filter is proposed.According to former movement targets information, kalman filter can estimate the initial position at the next moment, and then MeanShift algorithm can iterate it based on kalman filter. Compared with the traditional MeanShift algorithm, the improved method can obtain a stable tracking result when the target is totally occluded, as is shown in the following Figure 5

Figure 5. The tracking results of new tracking algorithm

6. Conclusion

A method in moving object detection is proposed in this paper. Texture and chrominance information are used in the background modeling, combing with the LBP operator, setting two threshold values to make multiple judgments. The changeof pixel gray value and the number of changed pixels are also used in detecting moving target. The experiments show that the proposed algorithm has strong adaptability to the environment. To some extent, it can resist interference caused by slight movements in the scene .What's more, in the process of moving object tracking, Kalman filter is used which combines Meanshift algorithm ,occlusion problem is solved.

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