An Improved Motion Detection Algorithm Based on ViBe

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Abstract. ViBe (Visual Background Extractor) algorithm is a kind of fast and accurate background subtraction algorithm, which is universally applied in video monitoring. The only drawback is the moving target in the first frame would introduce an artifact called ghost. In order to solve this problem, an eliminating ghost algorithm was designed in this paper. The algorithm depended on the foreground and the adjacent background area histogram and similarity measure. Because dynamic background video was easily influenced by background noise and interference, morphological image processing method was used in this paper. Experiments results show that the improved algorithm can quickly solve the ghost, foreground noise and holes problem.

Introduction

Moving object detection is verifying the present of an object in video sequence and locating it. It is one of the most important and difficult points in the field of computer vision and digital image processing. Optical flow method [1], Frame difference method [2] and background method [3] are commonly used to detect moving targets. Optical flow method is suitable for the stationary camera and movement. But this method is not only complicated but also easily affected by luminance change. And it is complex in operation, with bad Robustness. Frame difference method is easy in method and operation. But there easily occur Target is not incomplete and “holes” phenomenon inside of detecting result by frame difference algorithm. Compare with the first two, background subtraction is one of the most widely foreground detection methods in actual application. Firstly, algorithm model is built for image sequence, and background model of moving scene is obtained. Then the current frame of image compared with the background model to detect the moving object. The algorithm can detect foreground target accurately. But the accuracy depends on the background model. So the build and update the background model is very important for ViBe.

The current background generation technology has made great development. GMM (Gaussian mixture model) [4] is one of the representative Background generation methods. The method uses a plurality of Gauss model to describe background, and overcome the drawback that Single Gauss model cannot adapt to the complex environment. But the algorithmic build a plurality of Gauss model for each pixel point. So it has the high computational complexity and hard application problem of real-time response system. ViBe(Visual Background Extractor) is a visual background extractor algorithm. It has more and more attention because of its rapidity and accuracy. The algorithmic core is creating a sample using neighboring pixel points, and comparing it with each pixel point of the current frame to identify the pixel point as ghost or background [5].

ViBe algorithm makes the initialization very fast by using the first frame to initialize its background model, and the second frame begins foreground detection. But it will introduce ghost in actual application, which will affect the next analytical work. At present, many scholars have improved the algorithm in many ways [6-10]. Inspired by those previous studies, this paper presents an improved algorithm based on ViBe. Our group compares the foreground with the adjacent background area histogram and similarity to eliminate ghost. To reduce foreground noise and holes effectively, morphological image processing method was used.
ViBe Algorithm Analyses

The Principle of ViBe Algorithm

ViBe is a kind of nondeterministic video background modeling and foreground detection method. Specific algorithm steps are as follows:

**Step one: Background Modeling**

The algorithm uses the first frame to initialize its background model. For each pixel point, it uses the space distribution features that the neighboring pixel point has similar pixel value to identifies its pixel value of neighboring model as its sample value randomly. ViBe algorithm uses the sample (1) whose size is N to describe background model. The sample is identified by the pixel points of eight neighboring pixel models randomly.

\[ M(X) = \{v_1, v_2, L, v_N\} \]  

**Step two: Foreground Detection**

ViBe algorithm clustering based on pixel Euclidean distance and get the number of the intersection of \( v(x) \) and \( M(x) \), in the 2D Euclidean space-\( S_R(v(x)) \), with the pixel point of current frame as center and \( R \) as radius.

Compare (2) with the threshold \( \#_{\min} \), when it is smaller than \( \#_{\min} \), it was identified foreground target, otherwise, it was background.

\[ \#\{S_R(v(x)) \cap \{v_1, v_2, \cdots, v_N\}\} \]  

ViBe algorithm makes the initialization very fast by using the first frame to initialize its background model, so it can use the second frame to detect foreground.

**Step Three: Updating Background Model**

ViBe algorithm uses the Conservative strategy to update the background model, which means that foreground point cannot be the background model. It selected the new sample value for the sample with Uniform probability, which sure that the Smooth life cycle of sample point decay exponentially and show it is unrelated with time whether a sample of model be substituted or not. The updated strategy analog the nondeterminacy of pixel change to some degree, which improves algorithm’s adaptation of dynamic background.

The Drawback of ViBe Algorithm

ViBe algorithm detects the moving object very well and has good real-time, but it also has drawback, one of that is “ghost” problem. The ghost is the foreground area without actual moving target. ViBe makes the initialization very fast by using the first frame to initialize its background model. But when the first frame has moving target, ViBe will identify it as background to make model in error. The sampling background cannot match with the wrong background model, which causes background points were identified as foreground points and form the ghost. So it is important for ViBe algorithm to eliminate ghost.

By the impact of noise and dynamic background, the actual video is not ideal, resulting in detection results contain a lot of noise, for subsequent processing will also have an impact.

The Improved Algorithm

Eliminate the Ghost Area

To eliminate ghost, we compare the foreground with the adjacent background area histogram and similarity. Specific algorithm steps are as follows.

As shown in the Figure 1, \( S \) is identified as the bounding rectangle of foreground outline (for improving accuracy, the bounding rectangular length and width is extended two pixel, which is the
length and width of rectangle we got). SR is the foreground target of rectangle, SB is the rectangular background and \( S = SR + SB \). Calculating the histogram of SR and SB called HR and HB, we compared the similarity between the two histogram to judge the foreground target whether is ghost or not. If HR and HB have high similarity, we identify the foreground target as ghost. Otherwise, it is the real moving target. The result of the algorithm shown in the Figure 1(f), which proved the algorithm can eliminate the ghost accurately.

![Figure 1(a). The first frame.](image1)

![Figure 1(b). The 54th frame.](image2)

![Figure 1(c). The result of classic ViBe algorithm.](image3)

![Figure 1(d). The ghost areas and the moving target area.](image4)

![Figure 1(e). The bounding rectangle of foreground outline.](image5)

![Figure 1(f). The result of the improved ViBe algorithm.](image6)

Figure 1. “Ghost” problem.

Morphological Image Processing

For the background noise of video and the interference of dynamic background, morphological image processing method was used. That is repairing space and discarding small target.

**Step one: Repairing Space**

It uses open operation to remove noise and close operation to fill the small space of target. Through it, figure’s boundary will be smooth.

**Step two: Discarding Small Target**

1) Get the connected region of foreground image and get the aggregation of connected region, that
is $B_i \left( b_1, b_2, \ldots, b_m \right)$;

2) Traverse each connected region and get the number of pixel in the area;
3) If the number of pixel in the connected area less than 15, the area was given up and a new aggregation was got, that is $B_i \left( b_1, b_2, \ldots, b_n \right)$.

Experiments showed the method can remove small false target and get the real result. The comparison between classic ViBe algorithm and improved ViBe algorithm is shown in the Figure 2.

![Figure 2(a). The result of classic ViBe algorithm.](image1)
![Figure 2(b). The result of the improved ViBe algorithm.](image2)

Figure 2. Morphological image processing.

**Test and Verify**

To test and verify the performance of the improved algorithm, experiment was finished on Hardware platform: Intel Core i5, 4.0GB RAM, and software development environment: Windows10, VC++2015, OpenCV3.2.0.

![Figure 3(a). The first frame.](image3)
![Figure 3(b). The 54th frame.](image4)

![Figure 3(c). The result of the classic ViBe algorithm.](image5)
![Figure 3(d). The result of the improved ViBe algorithm.](image6)

Figure 3. Test and verify.
Figure 3(a) is the first frame, a car can be seen in it. Figure 3(b) is the 66th frame. Figure 3(c) is the result of the classic Vibe algorithm and clearly it was affected by the first frame, which leads the ghost area. Figure 3(d) is the result of improved Vibe algorithm and the improved Vibe algorithm can eliminate ghost effectively, which avoids the ghost influencing the subsequent processing. And using morphological image processing improved the validity of target and the performance of Vibe algorithm on the whole.

**Summary**

Based on classical ViBe model, the improved algorithm is designed and its practicability is better. The algorithm compares the foreground with the adjacent background area histogram and similarity to eliminate ghost effectively. Besides it uses morphological image processing to remove image noise and also adapt the interference of dynamic background, which improved the performance of Vibe algorithm on the whole.

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**References**


