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Video Moving Object Detection Based on Block Truncation Coding

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Abstract. *Moving object detection is the basic and key technology in computer video and image processing. In this paper, based on block truncation coding, a new moving object detection method which uses BTC to compress video frames and combines with the frame difference is proposed. This method mainly uses BTC to encode and decode video frames and then every original video frame or differential video frame is represented by high mean and low mean tables, which can be viewed as two down-sampling frames. After that, the motion parts can be detected by frame difference and threshold segmentation. The key of the algorithm is to use BTC to deal with the video frames in different stages. Experimental results show that using BTC to deal with differential video frame has the better detection effect and can eliminate the effects of small perturbations in the background very well.*
Keywords: Moving object detection, Block truncation coding, Frame difference, High mean, Low mean, Threshold segmentation

1. **Introduction.** Moving object detection is one of the key problems in computer video and image processing. It is a fundamental process and the basis of motion analysis and understanding about image sequences. It mainly detects, extracts and analyses moving targets in image sequences in order to achieve the goal of understanding the behavior of moving objects and completing a higher level task. Video target segmentation is based on static image segmentation algorithms, but it is not completely equivalent to static image segmentation. The key is to find the motion information and extract moving objects [1] through the research of single frame image processing.

With the rapid development of the Internet, people can easily obtain all kinds of information, including video clips. For the video clip captured by a fixed camera, the main methods to moving object detection include optical flow, frame difference and background subtraction[2]. However, a large number of images over the Internet are presented in the compressed domains, in view of the efficiency of storage and transmission. Several commonly used image compression techniques [3] are JPEG, JPEG2000, Vector Quantization (VQ) and Block Truncation Coding (BTC). Among these methods, BTC is the most simple and fast scheme with a relatively lower visual distortion.

Therefore, a video moving object detection method based on block truncation coding is presented in this paper. This method uses BTC to encode and decode video frames and then every original video frame or differential video frame is represented by BTC compressed high means and low means. Combined with frame difference and threshold segmentation, it can detect and extract foreground target pixels very well. In the experimental section, the effect of the BTC based detection scheme will be verified and compared in different block sizes and different priori thresholds respectively.

2. Block Truncation Coding of Single Frame Image.

2.1. BTC Compression Principle. Block truncation coding, which is a lossy image compression algorithm based on block encoding, was presented by Delp and Mitchell in 1979. It is a 1-bit moment preserving quantization method [4] that preserves the edge information of small blocks of the original image. BTC has the advantage of relatively good image quality while maintaining low computation effort. The main idea of BTC is to divide the original image into non-overlapping blocks of size n×n, each pixel in a block is replaced by either high or low mean. We set the average of each block as the threshold denoted as η. We set a as one reconstruction level representing pixels that higher than η, and set b as another reconstruction level representing pixels that lower than η. We use p and q to denote the numbers of pixels which respectively quantify for a and b. σ is the sample standard deviation. For each block, the values a and b are calculated as follows.

$$a = \eta + \sigma\sqrt{q/p} \tag{1}$$

$$b = \eta - \sigma\sqrt{p/q} \tag{2}$$

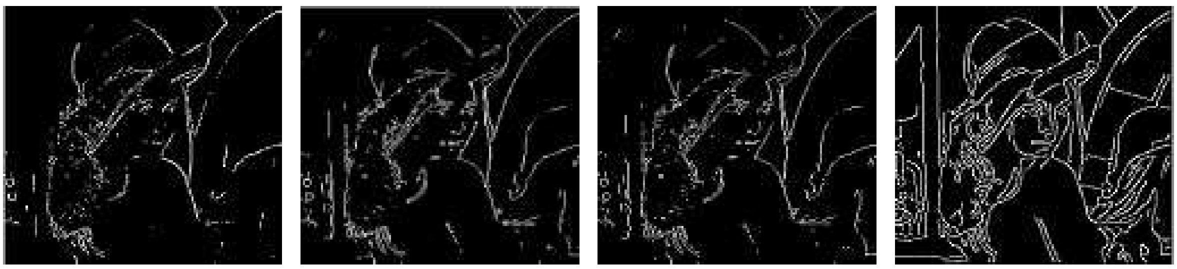
A bitmap [5] BM with the same size of each block is used to record the output of the BTC compression. The element in BM is set to 1 when the corresponding pixel in the block is greater than the mean value. Otherwise, it is set to 0. An example procedure of BTC can be described as follows.

$$\mathbf{x} = \begin{bmatrix} 136 & 27 & 144 & 216 \\ 172 & 83 & 43 & 219 \\ 200 & 254 & 1 & 128 \\ 64 & 32 & 96 & 25 \end{bmatrix} \rightarrow \boldsymbol{BM} = \begin{bmatrix} 1 & 0 & 1 & 1 \\ 1 & 0 & 0 & 1 \\ 1 & 1 & 0 & 1 \\ 0 & 0 & 0 & 0 \end{bmatrix} \rightarrow \mathbf{x}_{\boldsymbol{dec}} = \begin{bmatrix} 193 & 37 & 193 & 193 \\ 193 & 37 & 37 & 193 \\ 193 & 193 & 37 & 193 \\ 37 & 37 & 37 & 37 \end{bmatrix}$$

where

$$\eta{=}115,\ p{=}q{=}8,\ a{=}193,\ \ b{=}37$$

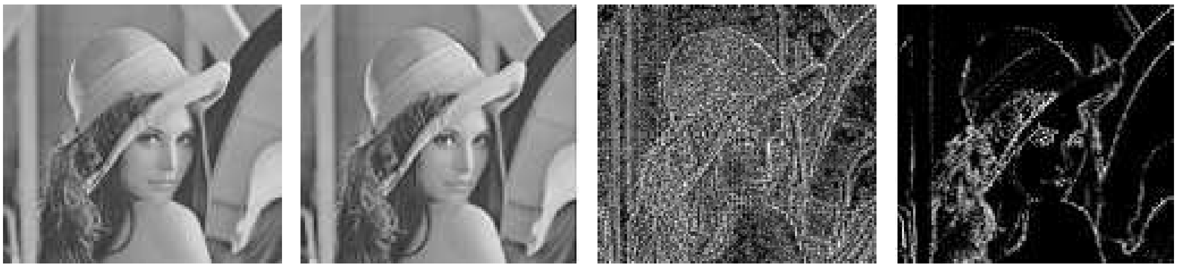
2.2. BTC Detection of Single Frame Image. Different image has different gray scale and the border will have obvious edge, which can be used for image segmentation. In the actual image segmentation, based on the first and second order derivative, all kinds of edge detectors have been widely used for image edge information extraction[6]. As is shown in Figure 1, testing result has more single lines.



(a) roberts (b) prewitt (c) sobel (d) canny

FIGURE 1. Edge detector for image edge information

The boundary of objects is not equal to edge, which pays more attention to regional extraction, not just a single line. Because of block processing and local identity, BTC is a good choice for regional extraction of the boundary of objects. We just simply use BTC to encode and decode each frame of the video sequence and calculate the difference between two adjacent decoded frames. After that, each difference image will be detected and segmented by threshold selection. This method can preserve the boundary of objects. One simulation example is shown in Figure 2.



(a) Original image (b) Decoded image (c) Difference image (d) Segmented image

FIGURE 2. BTC detection for the boundary of object

Compared to Figure 1, the segmented image in Fig.2(d) shows the character more complete, leading a better visual effect. Some areas is not only a single line. Using BTC can regional extraction on the boundary, and hence can be used for video moving object detection.

3. **Moving Object Detection.** When one video clip is captured by a fixed camera, the background image will not change greatly. In general, there will be a lot of pixels in the same pixel values in the background such as the wall, the road and the sky. The involvement of the moving target just causes the local change of background pixels and the background structure is relatively stable [7]. Therefore, in this paper, we use the theory of block truncation coding to block the image sequence to effectively eliminate the effect of local slight change in the background. Combined with the frame difference method, it can effectively detect the moving target.

As mentioned above, using BTC to process video frames in different stages, that is, different treatments after frame difference will produce different detection effects. In section 3.1, we use BTC to compress every original video frame. And in section 3.2, every differential video frame is dealt with BTC. These two methods both can detect motion parts in video frames, but detection results in section 3.2 has more ideal visual effect.

3.1. **Frame Difference Based on BTC Compression and Decoding.** In this paper,we use I_k(k=1,2,...)denotes the video sequence, $I_k(i,j)$denotes the pixel value in the location$(i,j)$of the *k-th* frame image, f_k(k=1,2,...)denotes the BTC decoded image sequence, $f_k(i,j)$denotes the pixel value in the location$(i,j)$of the *k-th* decoded image. Each pixel in the decoded image is replaced by either high or low mean. In order to make full use of the local identity brought by blocks, we calculate the difference between two adjacent frames. The difference image $d_k(i,j)$ after BTC decoding can be formulated as follows.

$$d_k(i,j) = |f_k(i,j) - f_{k-1}(i,j)| \tag{3}$$

Based on the frame difference theory, if $d_k(i,j) \le T$, we consider that the image is of little change, that is, without a moving target. If $d_k(i,j) > T$, it means that some moving targets appear. T is a priori threshold. The final difference image can be obtained as follows.

$$D_k(i,j) = \begin{cases} 1, & d_k(i,j) > T \\ 0, & d_k(i,j) \le T \end{cases} \tag{4}$$

Here, Threshold T is the key factor during the detection process. T will suffer conditions of various scenes, so it is important to determine the threshold T adaptively according to every frame.Generally, we can choose Otsu algorithm, which is a kind of automatic, nonparametric and unsupervised threshold selection method.

For the the difference image $d_k(i,j)$, using w_0 denotes the proportion of foreground points and the average gray level is u_0; using w_1 denotes the proportion of background points and the average gray level is u_1. Thus the total average gray level u_T for the image and the variance σ^2 are calculated as follows.

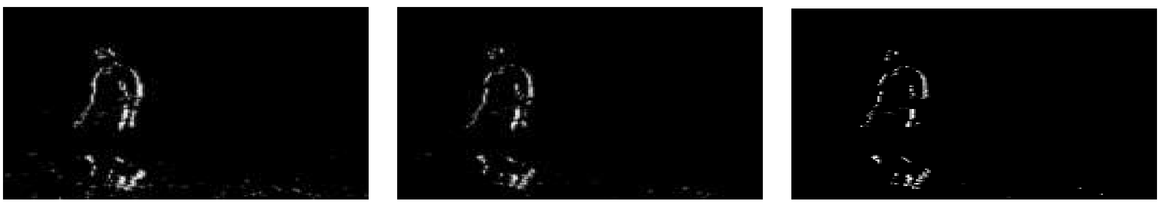
$$u_T = w_0 \times u_0 + w_1 \times u_1 \tag{5}$$

$$\sigma^2 = w_0 \times (u_0 - u_T)^2 + w_1 \times (u_1 - u_T)^2 \tag{6}$$

Traversing T from the smallest to the largest grey value, when T making the variance σ^2 largest, T is the best segmentation threshold. Based on variance between classes, Otsu algorithm is quick and has stable performance. It can obtain good segmentation effect in many cases. The correct selection of T ensures that the noise, interference and moving targets can be distinguished accurately.

When the size of block is different, the image quality and fuzzy degree of BTC compression and decoding will be also different. We need to detect the mutative pixels caused by moving targets, but this is a kind of local characteristics. However, block processing can just lead to local identity. It has a better adaptability to the local disturbance of the background and the change of moving objects.

In order to make an analysis in which various block sizes will generate different results and performances, simulation results respectively processed by 4×4 BTC and 8×8 BTC schemes are given below in Figure 3 and Figure 4. In our testing case, we choose different thresholds to compare the different detection effect.



(a) T=65 (b) T=75 (c) T=85

FIGURE 3. Results with the 4×4 BTC scheme

(a) T=65 (b) T=75 (c) T=85

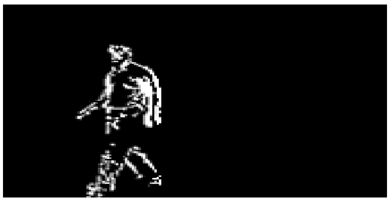
FIGURE 4. Results with the 8×8 BTC scheme

The figures above show that the proposed method can detect moving targets well and the approach itself has strong applicability. The larger the block size is, the better the effect of detection is. At the same time, using different thresholds, it will produce different noise points leading to different detection effects.

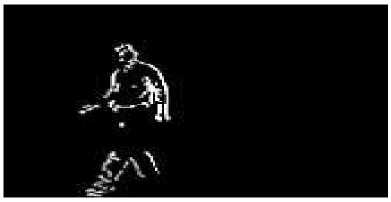
3.2. **BTC Motion Detection after Frame Difference.** As described above, if we use BTC to deal with the video frames in different stages, the detection effect will be obviously different. In this section, considering the advantages of block processing, we also puts forward a BTC based moving target detection method on frame difference. Firstly, we compute the difference image between two adjacent video frames. Then we use BTC to encode and decode each difference image. At last, we use threshold binarization to deal with every decoded image and segment moving objects. The processing procedure of this method can be formulated by Eq.(7) using the previous symbols in this paper.

$$|I_k(i,j) - I_{k-1}(i,j)| = d_k(i,j) \to f_k(i,j) \to F_k(i,j) = \begin{cases} 1, & f_k(i,j) > T \\ 0, & f_k(i,j) \le T \end{cases} \tag{7}$$

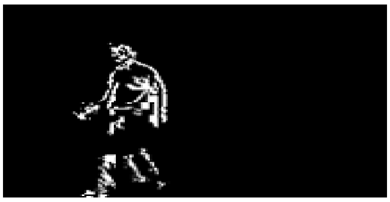
Because of BTC block processing, the size of block must have a decisive impact on the detection effect. Different block size has different performance. According to above theory, the detection effectiveness of the proposed approach in different BTC schemes is illustrated in Figure 5.



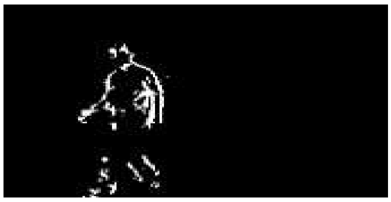
(a) 4×4 block size with T=20



(b) 4×4 block size with T=30



(c) 8×8 block size with T=20



(d) 8×8 block size with T=30

FIGURE 5. BTC detection results based on frame difference

BTC is a rapid and effective image compression method and has a strong practicability. Figure 5 shows the detection results of different frames on the same video using BTC processing detection after frame difference. This method can detect various characteristics of moving targets very well. The face and limbs of objects are clearly visible, which leads to an ideal detection effect. It can be found that many parts of moving objects are made up of blocks, that is, the target appears block by block. BTC processing, which is equivalent to block processing, will bring the local identity and promote the detection effect of video motion targets.

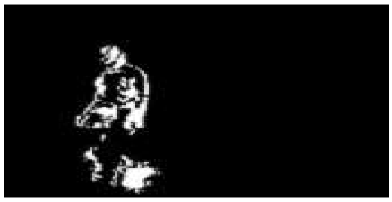
For the test video in this paper, the block characteristics of moving object will be more obvious if the block size is larger. It is the advantage of block processing. In addition, the smaller the threshold is, the more complete the detect target will be. Just as mentioned in section3.1, the selection of threshold for different testing video clips should be flexible in practice.

4. **Algorithm Performance Analysis.** Using BTC to process video frames in different stages will produce different detection effect. In order to verify the performance of BTC detection algorithm mentioned in Section 3, according to experiment results, this section makes a comparison in detection effect about BTC detection method and other methods, including direct frame difference and background subtraction. Comparing and analyzing the dynamic testing video, it can be clearly found that BTC detection will lead to an ideal detection effect.

(a) Direct frame difference

(b) Background subtraction

(c) Frame difference on BTC



(d) BTC on frame difference

FIGURE 6. The comparison of BTC detection and other methods

Detection results of direct frame difference and background subtraction are shown in Fig.6(a) and Fig.6(b).The detection effect of frame difference on BTC mentioned in section 3.1 comes in Fig.6(c).Being of vital importance, detection result of BTC on frame difference described in section 3.2, which is shown in Fig.6(d), has better detection performance.

Traditional frame difference method is on the basis of single pixel processing, Although frame difference can effectively remove the static background, the shortcomings of direct frame difference are that it cannot extract motion objects obviously and extracted target tends to be rough, leading a bad detection effect. Background subtraction requires the higher background modeling and background updating. It needs to quickly establish a background image and update the background timely. The approach must ensure to have the ability to adapt environmental change such as light and interference

BTC detection method proposed in this paper is based on block processing. Compared with a single pixel, a block can reveal more information about spatial distribution. Thus the detection method based on blocks will not be sensitive to local scene information change. It can filter out most of the background region and avoid using the background itself in motion detection. In addition, the detection border of video moving targets is relatively more complete and the detection result is better for moving objects [8].

Threshold binarization processing can make the border of moving objects appear while BTC processing after frame difference can make character profile clearer and the motion parts appear block by block. As is shown in Fig.6(d), using BTC processing, which means block threshold processing, figures will be fuller, not only just border. When there is a moving target in an area, the number of pixels in this area that is set to 1 will be larger and the edge characteristic of figures will be improved. Therefore, the whole characters can be detected more accurately. As a result, Using BTC to deal with the differential video frames will bring the most ideal visual inspection results.

5. **Conclusions.** Video moving object detection has wide applications in military visual guidance, video surveillance, medical diagnosis and intelligent transportation. Stable and reliable detection algorithms are important for high-level understanding of computer vision. This paper presents a detection method based on BTC. This method uses BTC block processing for video sequences and the introduction of high and low means will produce local identity. The proposed method is based on blocks rather than a single independent pixel. Experimental results demonstrate the strong adaptability of this method. Motion part is shown in block. Local identity can eliminate the effects of small perturbations in the background and make the extracted target boundary clearer and more complete.

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