

# An Effective Method to Detect Moving Objects under PTZ Camera

Huifen Dong<sup>1,a</sup>, Jiao Zheng<sup>1,b</sup>

<sup>1</sup> Robotics institute, Civil Aviation University of China, Tianjin, China;

<sup>a</sup>hfdong@cauc.edu.cn, <sup>b</sup>zhengjiao\_tj@163.com

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**Abstract.** Due to the changes of background, detection of moving objects under PTZ camera becomes critical and full of challenges. To solve this problem, a new method based on K-means clustering is proposed in this paper. Generally speaking, the motion vector of background is not equal to the motion vector of moving object, so that the moving target is extracted from the background. Gray projection method is used to extract Region of Interest (ROI). The global motion vector and motion vectors of blocks in ROI are obtained by block-matching method. K-means clustering is adopted to segment the moving target. By this way moving targets are detected accurately. Experimental results show that the method is not only suitable for fast-moving target, but can also extract the moving target under dynamic background quickly and precisely. So it is indicated that the method has some engineering value.

## Introduction

Accurate extraction of moving target is an important step in intelligent video surveillance, and directly affects the subsequent tracking, analysis or other treatment. Nowadays, most researchers have focused on moving targets detection under fixed cameras. Because PTZ camera is widely used in surveillance, it is of great importance to study moving targets detection under PTZ camera. The ordinary methods mainly include optical flow, background compensation and inter-frame difference method. Concerning optical flow method, it can be used in moving camera, but most of optical flow methods need to traverse all the pixels of the frame. The method is complicated and time-consuming, and it is also sensitive to noise and has poor anti-noise performance.

As for the background compensation method, the background variations are compensated, and then the detection under PTZ camera is converted into targets detection under static background. The motion vector of background is the key of background compensation. It is calculated by feature points matching or block-matching. Block matching method is suitable for horizontal or vertical displacement. In this paper the rotation and scaling are not considered, so the block matching method is appropriate for this application. The method is simple and highly precise, but it has a large amount of computation, low efficiency. So the block matching method is often combined with other algorithms for objects detection<sup>[1]</sup>. In order to reduce calculation amount, scholars continuously improve it in the search method<sup>[2]</sup>, matching criteria<sup>[3]</sup>, block selection<sup>[4]</sup> or other aspects.

## Extraction of ROI (Region of Interest)

Because the camera is PTZ camera, the background moves in and out of the field of view. The edge portion of the image always belongs to background. So edge blocks are suitable for calculating the background offset but not the foreground. These edge pixels of the image should be used when calculating the background offset.

The inter-frame background offset can be estimated by gray projection method. Image gray projection is the accumulated value of image gray value in vertical and horizontal direction. Vertical projection and horizontal projection of image are as follows:

$$\begin{aligned} Col_k(j) &= \sum_j Cur_k(i, j) \\ Row_k(i) &= \sum_i Cur_k(i, j) \end{aligned} \quad (1)$$

Where:  $Cur_k(i, j)$  is the gray value of position  $(i, j)$  in the image,  $Col_k(j)$  is vertical projection in the horizontal coordinates,  $Row_k(i)$  is horizontal projection in the vertical coordinates<sup>[5]</sup>. The vertical gray projection correlation of the  $k^{th}$  frame and the  $r^{th}$  frame is calculated as the following formula:

$$Colsub(j) = |Col_k(j) - Col_r(j)| \quad (2)$$

$$Csum = \left( \sum_{j=1}^m Colsub(j) \right) / m \quad (3)$$

Where,  $Colsub(j)$  is the absolute difference of the vertical projection,  $Csum$  is the average value of the vertical projection difference. After absolute projection subtracts the average projection difference, the series of results can be described by a correlation curve. Take the area whose correlation curve is greater than zero as ROI. But the edge portion of the image is easily affected by noise. In order to remove this impact, the image is filtered by cosine filter.

### Fast Block Matching

Global motion vector can be expressed as:  $\dot{d}(v, u)$ , where  $u$  represents the vertical shift amount,  $v$  represents the amount of horizontal movement. Block matching principle is shown in Fig.1. Search scope  $(m + 2r, n + 2r)$  is the maximum motion range of the image.

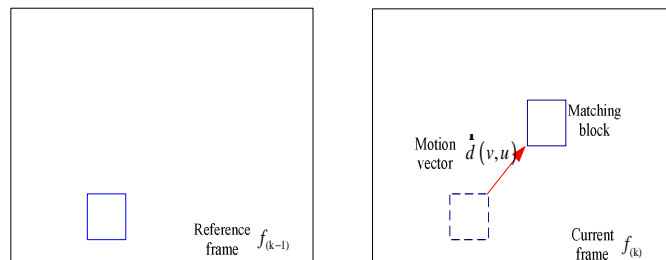


Fig.1 Principle of block matching

Mathematical expression is as follows:

$$\begin{bmatrix} x_0 \\ y_0 \end{bmatrix} = \begin{bmatrix} x_1 \\ y_1 \end{bmatrix} + \begin{bmatrix} c_1 \\ c_2 \end{bmatrix} \quad (4)$$

Here  $(x_0, y_0)$  and  $(x_1, y_1)$  are the coordinates of the reference image and the current frame, motion vector  $V = (c_1, c_2)^T$  describes the horizontal and vertical motion<sup>[6]</sup>.

SAD criterion is selected as block-matching criteria, because it is simple and convenient without multiplication<sup>[7]</sup>. SAD criterion is defined as follows:

$$\text{SAD}(v, u) = \sum_{i=0}^{N-1} \sum_{j=0}^{N-1} |f_c(i, j) - f_r(i+v, j+u)| \quad (5)$$

Where  $f_c(i, j)$  and  $f_r(i+v, j+u)$  separately denote pixels of the reference block and block to be matched,  $(i, j)$  represents pixel coordinates,  $N \times N$  is the block size.  $(v, u)$  expresses the displacement of the block. So the  $(v, u)$  is the best motion vector, when  $\text{SAD}(v, u)$  is the smallest value.

Usually in the scene, target is a small portion of the frame, while most part of the frame belongs to background. The motion vectors of background blocks are the same. Based on the constraint condition, a fast block matching method is proposed to extract the target.

1. Select the four corner blocks of the image to calculate the background motion vector using block matching method and majority rule. The result is the possible global motion vector, namely the background vector  $V_1 = (v_1, u_1)$ .
2. Motion vectors of all blocks in ROI are calculated by block matching method, the series of vectors are  $V_2 = (v_2, u_2), V_3 = (v_3, u_3), V_4, V_5, \dots, \mathbf{L}$ .

### Target Extraction

Motion vectors of these blocks in ROI are different from the background vector, so these blocks may belong to moving objects. In order to effectively detect and distinguish the different moving objects, the K-means clustering algorithm is used to extract moving targets<sup>[8]</sup>. Cluster center points are randomly selected, and then the following process is repeated until convergence.

For each block, the class which it belongs to is calculated as follows:

$$c_i = \arg \min_j \|x^{(i)} - m_j\|^2 \quad (6)$$

For each class, recalculate to update their central points:

$$m_j = \frac{\sum_{i=1}^m x^{(i)}}{m} \quad (7)$$

Convergence condition is as follows:

$$J(c, m) = \sum_{i=1}^m \|x^{(i)} - m_{c^{(i)}}\|^2 \quad (8)$$

Where  $k$  is the number of categories,  $c_i$  represents the pixel block nearest the class  $x^{(i)}$ .

Combined with contour detection, moving targets are detected. The detected targets may contain some noise pixels, so the blocks whose areas are less than the threshold are discarded.

### Experimental Results and Analysis

Based on the proposed method, a series of experiments have been implemented using Matlab (2011R) for image processing. Three videos recorded by a PTZ camera surveillance platform are used to verify the feasibility of above method. And this method is compared with the method combining Block-Matching with Frame-Subtraction (BM + FS). The image size of the experiments is  $704 * 576$ .

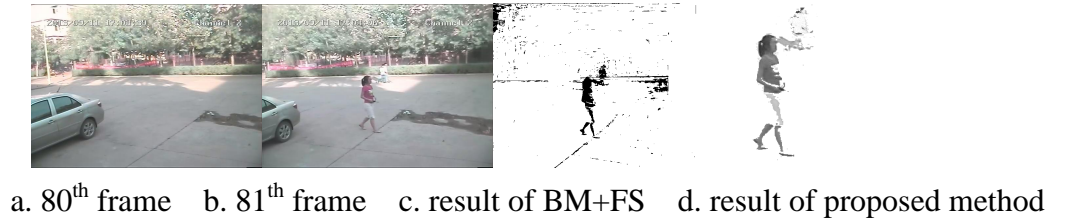


Fig.2 Test results of scenario 1

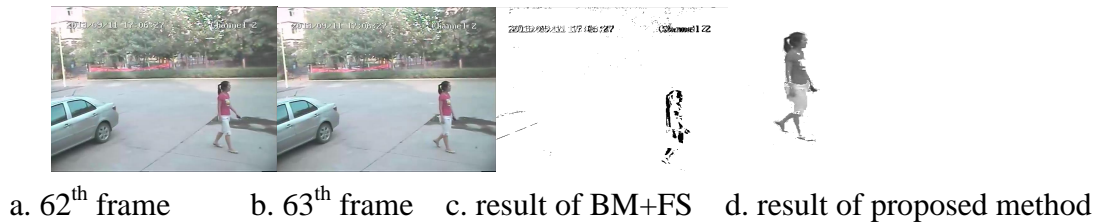


Fig.3 Test results of scenario 2

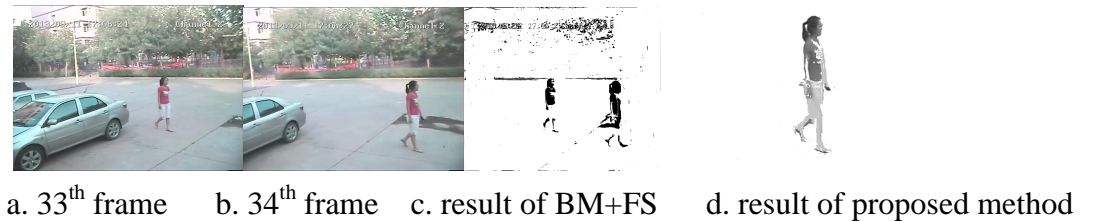


Fig.4 Test results of scenario 3

In scene 1 (Fig.2) the camera moves fast and the target suddenly appears in the view, the target detection results are shown in Figure c (Block-Matching+Frame-Subtraction) and d (method of this paper); In scene 2 (Fig.3) the camera moves fast while target velocity is slow, the target can be detected by both methods, but the result of BM+FS method (Figure c) is a cavity of the target; In

scenario 3 (Fig.4) both camera and the target move fast, BM+FS method (Figure c) detect the same goal as two separate false detection objects, while the proposed method can correctly detect moving target. Comparison of time consumption of two methods is shown in Tab.1.

Tab. 1 Time of this method and BM+FS

The method	BM+FS	Method of this paper
Time consumption of first scene (ms)	516	171
Time consumption of second scene (ms)	230	98
Time consumption of third scene (ms)	701	196

## Conclusions

In this paper, an effective method of moving target detection under PTZ camera based on K-means clustering has been proposed. The approach has been compared with the method combining Block-Matching with Frame-Subtraction. The method can effectively extract the target region rather than compensate dynamic background, reduce the computational amount of block matching and improve the processing speed. It can also improve the accuracy of detecting moving objects.

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About the Authors:

Huifen Dong: (1970-), female, Hebei Tangshan, associate professor, Ph.D., research area: power electronics and motor control, aircraft power supply systems and robot control;

Jiao Zheng: (1988-), female, Shanxi Xinzhou, graduated, the main research area: navigation, guidance and control.

## References

- [1] WANG Ning: Detection and tracking of moving object based on self-localization robot. Jinan University (2014).
- [2] YU Fei, LIN Zhe, ZHAO Yue-jin, DONG Li-quan, KANG Xiao-jun: A fast motion estimation searching method based on the multi-start and concurrent algorithm. Optical Technique, Vol.40 (2014),p. 140-144
- [3] DENG Zhi-chao: Motion estimation algorithm for efficient video coding inter prediction. Chongqing University(2014).
- [4] LU Zi-wei, WU Cheng-dong, CHEN Dong-yue: Fast block matching motion estimation algorithm based on spatial correlation prediction. Journal of Northeastern University (Natural Science),Vol.35 (2014),p. 470-474
- [5] ZHAO Zhi-qiang, CHEN Ying: A fast image stabilization algorithm of video sequences based on gray projection and block matching.Opto-electronic Engineering,Vol. 38 (2011),p. 146-150
- [6] ZHU Xiao-hong, LIU Dong-hai: Motion estimation algorithm based on multi-path small diamond search pattern. Computer Engineering and Applications, Vol. 47 (2011),p. 141-144
- [7] ZHANG Jia-yi,LUO Xi-ling,HUANG Zhi-gang: Optimization of multi-mode motion estimation algorithm in H.264,Vol. 34 (2008),p.140-143
- [8] XU Cheng,HUANG Da-qing: Detection of moving objects in dynamic scenes based on robust M-estimator and Meanshift clustering.Acta Photonica Sinica,Vol.43(2014),p.1-6