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Extended Target tracking using projection curves analysis and matching Pixel count

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Abstract: *A novel algorithm for detecting and tracing extended target using projection curves analysis and correlation tracking based on the maximum matching pixel count (MPC) criterion is presented. First, the projection curves of the difference image of two consecutive frames are analyzed to find the approximate areas of moving target on the entire scenes. Then correlation tracking based on the improved MPC criterion is used for target tracking against the cluttered background. Experimental results show, as compared to the conventional approaches, the proposed algorithm is more robust, has higher precision, and has simplified computational complexity for tracking an extended target against a cluttered background.*
Keywords: *MAD, MPC, NCC, MSE, CTA*

I. Introduction

There are many tracking methods for different targets and for targets in different moving states. When the target is moving close to the camera, its image area in the field of view (FOV) will gradually increase. The target in this state is generally called an extended target. In a real-time imaging tracking system, it is hard to accurately locate an extended target because of the gray-level overlapping between the targets.

The correlation tracking algorithm (CTA), based on image matching, is one of the most efficient technique for tracking an extended target. Some of the most commonly used matching criteria are the mean absolute difference (MAD), the mean squared error (MSE), the normalized cross correlation (NCC), and the matching pixel count (MPC). However, application to a real-time tracking system was limited because of the complex environment.

Many researchers have provided object tracking algorithms to sum a verity of applications, including vehicle tracking, medical diagnosis, surveillance, and military applications under a cluttered background.

Background subtraction and background motion compensation are also commonly used for detecting and tracking objects. Its tracking capacity strictly depends on the accuracy of background modeling, and if often fails under noisy, complicated background or without any a priori information or any constraint with respect to the camera's position or the object's motion.

Optical flow estimation could be an efficient approach for tracing objects but its application in real-time systems was limited due to high computational complexity and sensitivity to noise. In order to degrade the computational complexity improve real-time tracking performance, a novel algorithm for detecting and tracking extended target using the projection curves analysis and correlation tracking based on maximum matching pixel count **(MPC)** criterion is presented . First, the projection curves of the difference image of two consecutive frames are analyzed to fine the approximate areas of the moving target on the entire scenes. Then correlation tracing based on the improved MPC criterion is used for target tracing against a cluttered background. Experimental results show, compared to the conventional approaches, that the proposed algorithm is more robust, has higher precision, and has simplified computational complexity for tracking and extended target against a cluttered background. In section 2 we explained the capturing of the object through projection curves, in section 3 we explained the conversion of object into pixels in section 4 we have given the experimental results in section 6 we have concluded with our phenomenon and with future scope of this proposal.

II. Projection Curve Analysis

In Real-time it is used for detecting, tracking, and guiding aircrafts or panzers near the ground. Before the closed –loop tracking, it is need to capture the object in several previous frames of video taken by monitors as quickly as possible. The camera could be considered a stationary. Moreover, the high frame-rate camera used for this system is up to 70Hz, and the displacement of moving object with in consecutive frames is less than a pixel. The difference image of two consecutive frames in video taken by static monitors in the initial stage for capturing the target shows the areas of moving targets because the background is almost invariable between consecutive frames. The method using frame difference image has simplified the computational complexity[1].

In this research it is supposed that $\mathbf{P_k}$ **(k=1, 2, 3…..)** is the K_{th} frame of the monitoring video with resolution of M×N pixel.

$$\mathbf{D_t = P_{t+1} - P_t}$$

Is the difference image between time **t** and **t+1**.

In addition, suppose that the target's gray level is always brighter than the background. If the pixel P_t (i,j)belongs to a bright moving target in position (i,j)at time t, and P_{t+1} (i,j)belongs to the dark background in position(i,j) at time t+1 then D_t(i,j) should be positive . On the contrary, $\mathbf{D_t}$ **(i, j)** should be negative. So in this case, define the difference image for positive and negative cases as fallows.

$$\mathbf{D_{pt}(i,j) = D(i,j) \;\; if\; D(i,j) > \tau \;\; and \;\; 0 \;\; otherwise} \quad \text{---- (1)}$$

$$\mathbf{D_{nt}(i,j) = |D(i,j)| \;\; if\; |D(i,j)| > -\tau \;\; and \;\; 0 \;\; otherwise} \quad \text{----(2)}$$

Where τ is a threshold. Suppose that $\mathbf{D_{pt}}$ consists of those pixels belongs to targets in Pt and belonging to the background in P_{t+1} thus in this case define

$$f_u(m) \;=\; \sum_{n=1}^{n=N} \mathbf{D\,pt\,(\,i,\;j\,)} \qquad m=1,2,3\ldots\ldots\ldots\ldots,M. \qquad \text{---------- (3)}$$

$$f_v(n) \;=\; \sum_{m=1}^{m=N} \mathbf{D\,pt(\,i,\;j\,)} \qquad n=1,2,3\ldots\ldots\ldots\ldots,\; N. \qquad \text{---------- (4)}$$

Where $\mathbf{f_u}$ **(m)** is the horizontal projection curve and $\mathbf{f_v}$ **(n)** is the vertical projection curve of $\mathbf{D_{pt}}$

For D_{pt} and D_{nt}, there is a total of four projection curves, which can be denoted with $\mathbf{f_{pu}}$(m),$\mathbf{f_{pv}}$(n), $_{nu}$(m) and $\mathbf{f}_{nv}$ (n) , respectively. In this research can analyze these curves as follows steps.

1. Image preprocessing; include noise reduction and curves smoothing.
2. $\mathbf{f_{pu}(m) = max_{m=1}\, \mathit{M}\, (f_{pu}(m))}$; find m1 and the range (i1,r1) of the relative wave peak.
3. $\mathbf{f_{nu}(m) = max_{m=l1}\, \mathit{r}1}(f_{nu}(m))$; find m1 and the range(i1,r1)of the correlation wave crest.
4. Remove the wave crest just found.
5. Repeat steps 2 and 3, until $\mathbf{max(max(\, f_{pu}(m)),max(\, f_{nu}(m))) < \varepsilon}$
6. do the same process for $f_{pv}(n)$, and $f_{nv}(n)$; then in this research can find all the possible areas of moving targets.
7. Repeat steps 2-6 in all possible areas until they could not be divided.

Figure 1: Sample object as a rectangle for target estimation

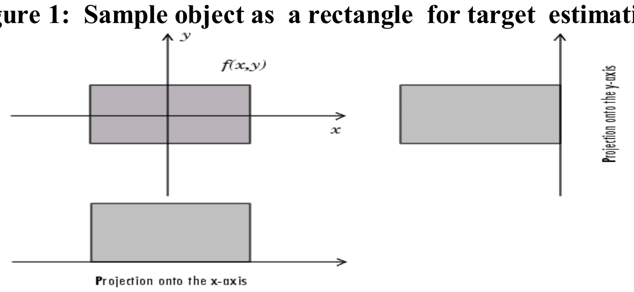


Figure 2: Sample object as a Square for target estiamtion

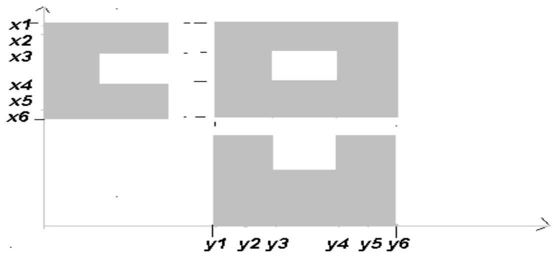
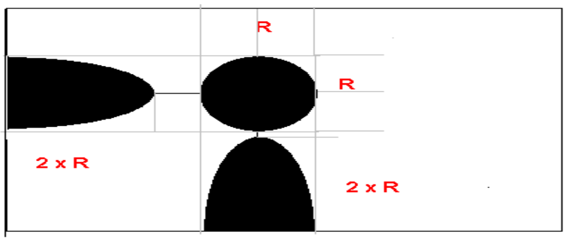


Figure3:Object moment target estimations



The pairs of wave crest represent a possible moving target in projection curve analysis.A result of analyzing curves that illuminates a possible area of a moving target where y1, y6, x1, x6 denote the possible areas containing a moving target.

III. Correlation Tracking Based On Mpc Criterion

From [2] [3] each pixel in a search image is categorized as a matched pixel or a non-matched pixel according to the MPC criterion, which can be formulated as the following expression.

$$T(i,j;x,y) = I|\ i(i,j,k) - i(i+x, j+y, K+l)\ | \leq th,$$

And

$$T(i,j;x,y)=0 \quad \text{Otherwise} \quad \text{------------- (5)}$$

Where th is a predefined threshold, and I (i,j,k) is the intensity of the pixel at location (i, j) in a searching block in the k_{th} frame .the motion estimation of the searching block B is given by

$$MPC(x, y)= \sum_{(x,y)\epsilon B} T(i,j;x,y) \quad \text{----- (6)}$$

And

$$[\hat{x},\hat{y}]^{T}=^{arg}\max_{(x,y)\epsilon B} MPC(x,y) \quad \text{,------ (7).}$$

Where is the estimation value of (x, y), which gives the maximum number of the matched pixel ($\hat{x}$, $\hat{y}$) ls.

3.1 IMPROVED MPC CRITERION

The traditional definition of MPC in Eq (5) efficiently can restrain the effect of noise. However, it counts the number of matching pairs of correlative pixel but does not consider the matching performance of their pairs, which also denotes the correlation of two image blocks. Therefore, we change the definition of MPC in Equ (5) as follows.

$$T(I,j;x,y) = th' - |I(i,j,k) - I(i+x, j+y, K+l)| \qquad \text{if} \quad |I(i,j,k) - I(i+x, j+y, K+l)| \leq th'$$

$$T(i,j;x,y) = 0 \quad \text{otherwise} \quad \text{---------------- (8)}$$

Where th’ is also a predefined threshold that is somewhat different from th in Eq (5) , and its value is usually less that **th**.This new definition of MPC considers the effect of matching performance of each matching pair and can improve the tracking precision.

3.2. ADAPTIVE PIXEL THRESHOLD

Applying a constant threshold th’ to all cases in real-time environment is difficult. Therefore, an adaptive pixel threshold that can determine the most important portion of the computation in the change detecting for a frame is rather critical.

The threshold selection for image segmentation and motion detection was studied over 10 year ago. Two of the simplest methods for selecting adaptive threshold are based on combining the mean value with the variance of image data and the histogram-based approach. However, they are usually used for single-frame images or stationary image processing. The motion estimation procedure requires a threshold for separating these two kinds of blocks. Shi and Xia presented a thresholding multi-resolution block matching algorithm using a predefined **MAD** value to filter out inefficient blocks before further block matching. Another method is a histogram-based approach to threshold selection is derived under the assumption that the histogram generated from the intensity difference between two gray-level frames contains three values combined with additive Gaussian noise. Both of these algorithms perform well in terms of the trade-odd between time and distortion. However, the threshold values are predefined and obtained by offline computation .many experiments must be conducted to obtain feasible constant threshold values for various video sequences. In our real-time tracking system, the pixel threshold **th’** is just considered as a pixel counter for judging the correlation between two frames of video, rather than as the gray-level value of a pixel for segmenting image. Here **th’** is a special pixel threshold tracking based on the MPC criteria

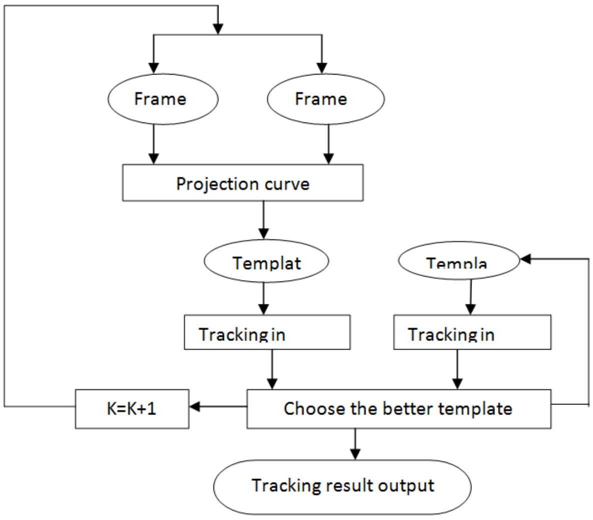
Before searching a motion vector in the search area, a direct prediction uses the same block (M×N) in the reference frame. Here, the prediction error, termed the initial MAD (IMAD) for each block, is defined as

$$IMAD=\frac{1}{M\times N}\sum_{i,j\epsilon B}[I(i,j,k) - I(i,j,k-1)] \text{,---- (9)}$$

Where I (I, j, k) denotes pixel value at the (i, j)position in the current frame k and I (i, j, k-1) represents the pixel value at the same position in the previous frame. Then in this research can define the adaptive pixel threshold as **th’= λ ×IMAD**, Where λ is a coefficient that can be set like 0.8-1.2

3.3 TEMPLATE UPDATING

In this research propose a new approach for updating the template combining projection curves analysis, shown in fig



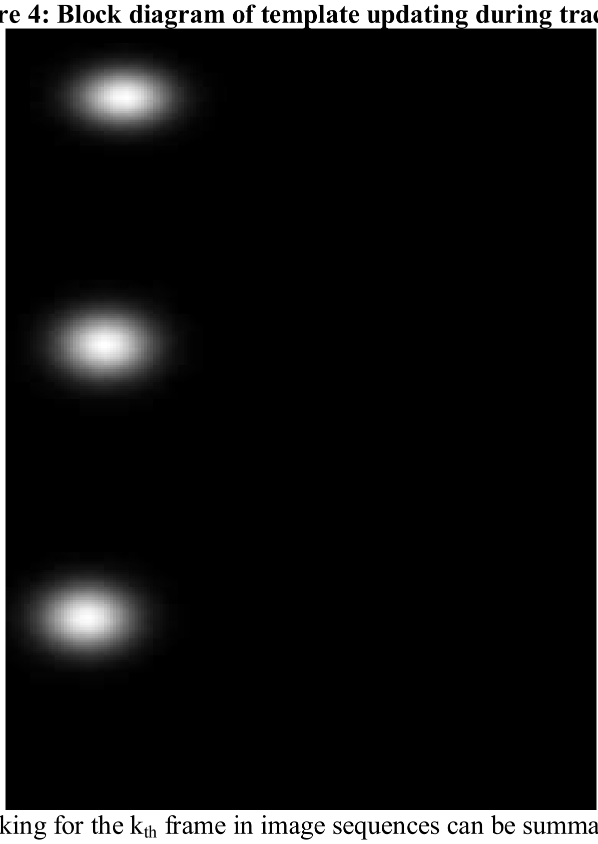
In practice, if in this research take the current frame at the optimal Matching position as the template for the next frame matching, the tracking point is easy to drift onto the background from the correct position because of the large motion or the abrupt change of the pixel intensity in some frame. With accumulating error during tracking, it is more likely to lose the racking point of the target in FOV. Therefore, it is necessary to take account of updating the template by combining the previous template with current frame near the $(\hat{x}, \hat{y})$ position. This approach provides timely guidance for the tracking procedure, so that in this research obtain good tracking results.

The traditional method for template updating is generated by using an infinite impulse response (IIR) filter of the form.

$$\mathbf{M_{k+1} = \alpha Ik+1 + (i-\alpha)\, M_k,}$$

Where Mk is the previous template in the current position, I_{k+1} is the block of the current search near the $(\hat{x}, \hat{y})$ position, α is an adaptive weighted coefficient, which can be defined as **α= d $_{MPC}$/A (M)** ,**d $_{MPC}$** is the MPC value between the previous template and the current searching block at the $(\hat{x}, \hat{y})$ position, and A(M) is the total pixel of the template i.e. The template area. This approach for updating the template may be invalid because of the abrupt change of the pixel intensity and partial occlusion for the target.

Figure 4: Block diagram of template updating during tracking



The main step of target tracking for the k_{th} frame in image sequences can be summarized as follows.

1. Search the best matching block (block 1) of the current template (template 1) in frame k.
2. According to the projection curves analysis in frame difference image of frame k-1 and k, in this research get a new possible area of the target that is correlative with template 1. Then template 2 can be determined by choosing suitable block in it.
3. Searching the best matching block (block 2) of template 2 in frame k.
4. Replace the current template (template 1) using the better one by comparing block 1 with block 2.
5. **K=k+1;** so back to step1.

IV. Experimental Results

In order to evaluate the performance of the proposed algorithm, a series of computer simulations has been conducted using image sequences from a real scene.

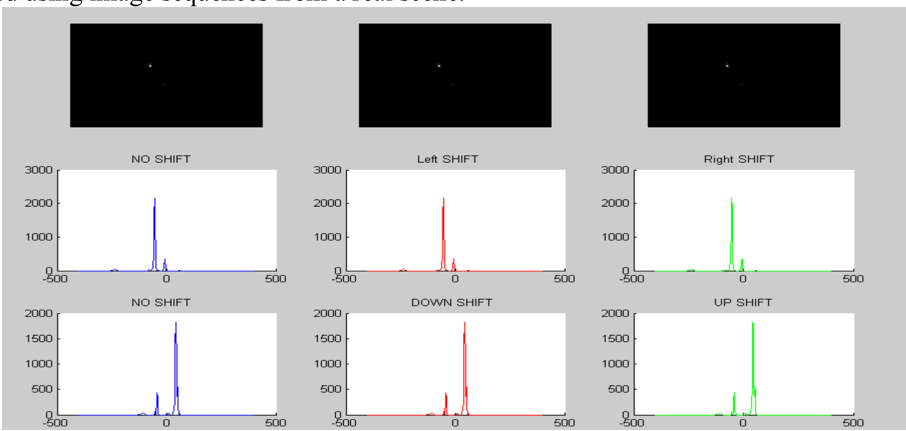


Figure 6: Object estimation by projection Curve analysis.

Figure shows the three frames (#82, #89, #96, #107, and #113) of a video sequence (360×252 pixels per frame) taken by a static camera, where a moon is moving along the sky, with a cluttered background. The proposed algorithm can successfully locate it over the full course of the object's removing, even the partial occlusion occurred during tracking. The white rectangle presents the tracking gate, and its size is 128×64. In this research calculated the correlation curves for frame 101 of the video sequence by using the conventional MAD and the proposed approach, respectively, while the object is located that the correlation curves if the proposed method near the optimal position is sharper than the MAD'S. Therefore, the method combining projection curve analysis with improved MPC correlation tracking can overcome the drawback of conventional approached, which correlation curve peak is indistinguishable, especially under the noisy and cluttered background.

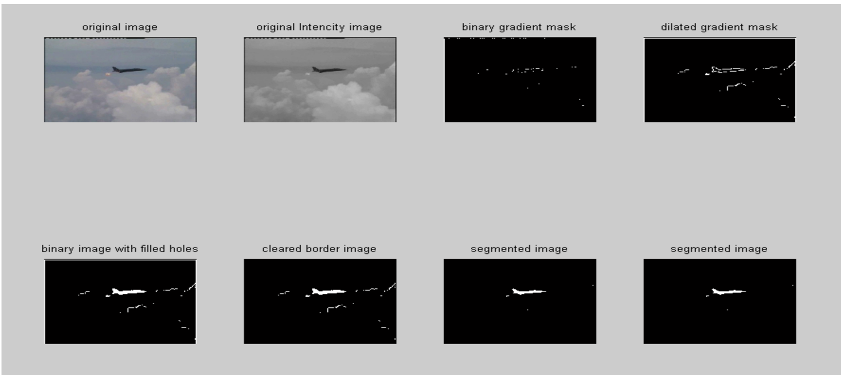


Figure7: Airplane estimation by Matching Pixel count.

Figure show the frame images (#41-46, 512×512
Pixels per frame, and 115 frames in all) of battle planes taking off. It's a real scene characterized background with low STCR. In this research tracked the airplane head using MAD, NCC the conventional MPC (with fixed threshold 12 and fixed matching template) ,and the improved algorithm, respectively. The template size is 16×16, and the church algorithms adopted full search (FS) for all approaches. The average MSE of 55 frames arranged at intervals of one frame from the whole test sequence using different approaches is shown in Fig 6. The good performance of the presented method can be easily observed from this figure,

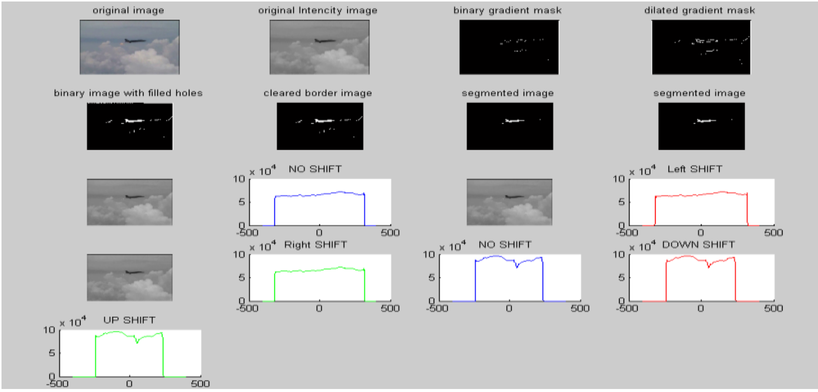


Figure7: Airplane estimation by Projection curve Analysis

Especially in the area where large motion is involved. In order to quantitatively evaluate the proposed algorithm the statistical MPC, and the improved algorithm in terms of mean-square error (MSE) between the estimated frames and the original frames, running time for finding the optimal target position per frame and false alarm rate for to two experiments, are given in table .

V. The Performance Comparison Of Several Approaches For Tracking Objects From Two Real Scenes.

		mad	ncc	The conventional MPC	The proposed algorithm
Scene 1:	**Average MSE**	3.3	3.3	2.88	2.21
object	**Average running time(ms)**	57	64	49	42
O	**False alarm rate (%)**	10	3.4	1.8	0.8
Scene 2:	**Average MSE**	5.6	5.5	4.35	4.42
Airplane	**Average running time(ms)**	141	185	134	136
head	**False alarm rate (%)**	30	11	4.8	0.9

Table 1: Comparison of the different algorithms

Notice that the false target or tracking point deviating from accurate position to all frames during tracking, rather than the false rate to classify the pixel as foreground or background. The comparisons for MSE, running time, and false alarm rate show that the improved method achieved better performance than the other three algorithms.

VI. Conclusions

In this research present a new approach for extended target tracking against a cluttered background using projection curves analyzing difference image and correlation tracking based on the improved MPC criterion with adaptive threshold and template updating. The proposed algorithm is not sensitive for single noise and is especially efficient when overcoming the influence when it target was locally hidden, distorted, or of acutely varying illumination. Moreover with very large-scale integration (VLSI).notice that the proposed method can be combined with the searching algorithms to solve the time-consuming problem in future work.

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