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# Application of Moving Object Tracking Based on Kalman Filter Algorithm

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**Abstract:** The moving object module matching method base on Kalman Filter (KF) algorithm which proposed to solve the problem of traditional moving object matching method's, that fault of huge searching range and weakness in real-time processing. Relative to traditional module matching method, the method mentioned here effectively improved the speed and the accuracy of object tracking. This method has tripled the object matching speed of traditional tracking method.

**Key words:** Moving object tracking, template matching, kalman filter , algorithm

## INTRODUCTION

Image sequence which is research object of moving object tracking, refer to monitor the space-time variety of the moving object in entire video sequence. Such as the location, form and dimension, or appears and disappears of the object.

Background noise, illumination, shadow, the shake of the camera and the obstruction from other moving object also bring a great challenge to accuracy tracking of the moving object. In the real-time observe of vehicle, human and airplane in busy traffic environments is often needed. In other field of moving image coding, traffic monitoring and military field, the moving object tracking is also needed. Video sequences are needed for processing. The purpose of tracking of moving objects in image sequences technical is to combine the image processing, automatic control, information science technologies to form a solution which can detect the moving object from the image information and process the real-time tracking of the extracts location information. In a simple word, find the exact location of the object in the next image. A simple way of track method is extract the image form a template, then find the most matched location in the next image use the entire image searching match method. Some times we can get the satisfying result by using this method but also have various problems in the reality application. In one side, this method need huge complicated calculation and was too hard to achieve, if the object image was distorted by the object swirling, light changing and target moving in the next image, we can't get the expected matching result by using the pixel data of image as the matching template.

So, we propose the Kalman Filter (KF) based on the template matching method to forecast the object location in next image, decrease the searching region of the object to achieve the fast object detection and calibrate the speed of the object to achieve exact object detection.

## TEMPLATE MATCHING BASED ON MOVING OBJECT

From a fixed location of images there are tupper-left pixel of the image to begin the point-by-point match by using template matching method. This algorithm is relatively simple and easy to understand but need very large amount calculation, using some calculation techniques during the operation, you can match the image line by line, such as coarse-fine sampling after match; changing the template size; removal of obviously no objective measures such as speeding up the matching speed.

Template matching method is defined as matching the image with the character template of object, detect the object in the specific rule and detect the known shape object in specific image. Matching the fixed area of one image with the other image (Wren *et al*., 1997a). By using the matching method, someone can recognize the fixed object which was shot in different angle and get the 3D parallax, the height and depth of the target object.

If the template T was shift over the searching image F, the searching area covered by the T in F is called subgraph $F^{i,j}$, the reference point i, j is the pixel in the top left corner coordinates of the subgraph $F^{i,j}$ in the figure F. Suppose the size of template T is P×Q, the size of F is M×N and the range of I, j is: $0<i<M-P+1$, $0<j<N-Q+1$ (Wu, 1993).

Compare the content of T and $F^{i,j}$, if the two agree and the difference of T and $F^{i,j}$ is 0. We can use one of the following two kinds of measure method to measure the similarity between T and $F^{i,j}$:

$$D(i,j)=\sum_{m=1}^{P}\sum_{n=1}^{Q}\left|F^{i,j}(m,n-T(m,n)\right|^2 \tag{1}$$

$$D(i,j)=\sum_{m=1}^{P}\sum_{n=1}^{Q}\left[F^{i,j}(m,n)-T(m,n)\right]^2 \tag{2}$$

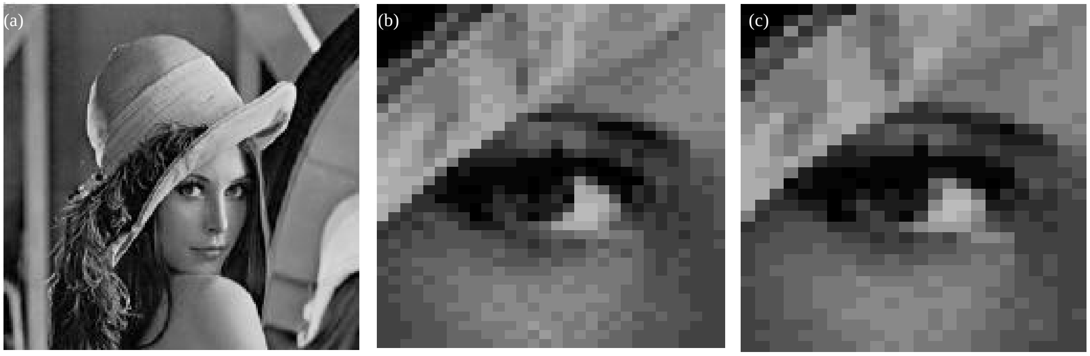


Fig. 1(a-c): A example of template matching methods, (a) Original image, (b) Template and (c) Matched image

Because the template must (M-P+1)×(N-Q+1) in the reference position carry on the match in, is lights besides a spot in the non-match does not studiously, the operating speed is slow, cannot achieve the real-time examination the request. Figure 1 is a template matching example (Wren *et al*., 1997b).

The main algorithm is with the template which withdraws in the image carries on the comprehensive retrieval, preoccupies with the template region same size region, with this region and template's match, namely obtains this region and the template bad sum of squares, circulates unceasingly, is retrieved until entire image's each region, extracts two chart aberrations is zero region, because the majority movement target shape is not only, therefore, obtains the difference the sum of squares smallest spot region for the goal in the region.

## TEMPLATE MATCHING ALGORITHM BASED ON KALMAN FILTER

The template matching algorithm based on Kalman filter can decrease the dynamic searching region and improve the real-time ability of the conventional template matching method, it is a linear recursion filter, it can give the optimal estimate of the next statement according to the current statement sequence, stable and optimal. The Kalman filter algorithm to consist of two state equation and observation equation.

System state equation:

$$x_k = \phi_{k,k-1}x_{k-1}+W_{k-1} \tag{4}$$

observation equation:

$$Y_k = H_K x_K+V_k \tag{5}$$

where $x_k$ is a n×1 dimensional state vector of the system state, $Y_k$ is the m×1 dimensional state vector of observed system state, $\phi_{k,k-1}$ is a n×n dimensional state transform matrix form times $t_{k-1}$ to times $t_k$, $H_k$ is a m×n dimensional observation matrix in the moment of $t_{k-1}$, $v_k$ is a n×1 dimensional random vector of random obstruction (flat noise) in the moment of $t_{k-1}$, $V_k$ is a m×1 dimensional vector of observation noise in the times $t_k$ (Olson and Brill, 1997).

Presume the dynamic noise $W_k$ and the observation noise $V_k$ was two unrelated normal flat noise sequence which's dc voltage average value was zero (Fan *et al*., 2000). Define the $Q_k$ and $R_k$ as the covariance matrix of the dynamic noise $W_k$ and observation noise:

$$V_k{:}\phi_k = \{W_k\, W_k^{k-1}\} \tag{6}$$

According to $Y_1$, $Y_3$, $Y_3$,... $Y_k$ estimate the $x_1$ is called Kalman filter and according $Y_1$, $Y_3$, $Y_3$,... $Y_k$ to estimate the $x_{k-1}$ is called Kalman predict or forecasting. Via the Kalman filter to renew the system current state $x_k$ and via the Kalman predict to estimate the system future state $x_{k-1}$.

If $W_{k-1}$ and $V_k$ fit specific assumption then they were known t, Because of the system was fixed, $\phi_{k,k-1}$ and $H_k$ were known, . Define the $P_k$ as the covariance matrix of $\hat{x}_k$ and define $P'_k$ as the aberration covariance matrix of $x_k$ and $P'_k$. We got the equation of Kalman filter algorithm: In time $t_0$, initialize $\hat{x}_k$ with the equalizing value vector $\chi$ and then got the $P_0$.

In time of $t_k$, the state estimate equation was:

$$\hat{x}_k = \phi_{k,k-1}\hat{x}_{k-1} + K_k\left(Y_k - H_K\phi_{K,K-1}\hat{X}_{K-1}\right) \tag{7}$$

$$P'_k = \phi_{k,k-1}P_{k-1}\phi^T_{k,k-1} + Q_{k-1} \tag{8}$$

$$K_k = P'_k H^T_k (H_k P' H^T_k + R_k)^{-1} \tag{9}$$

$$P_k = (1-K_kH_k)P'_k \tag{10}$$

$K_k$ was the gain factor matrix.

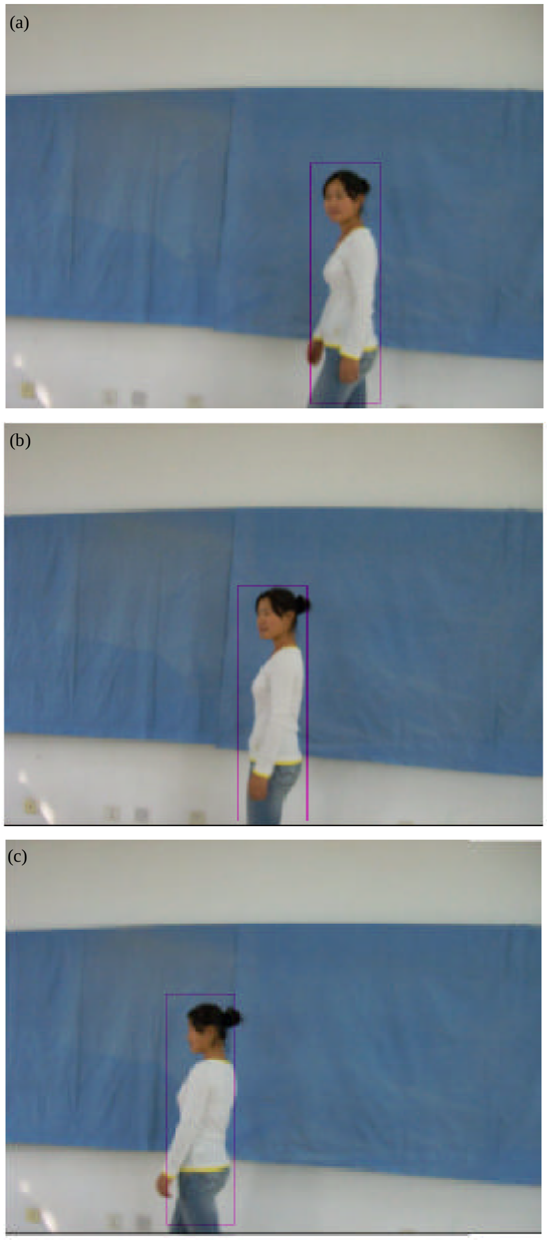


Fig. 2(a-c): 1th-3th frame

According to principle of Kalman filter, when tracking the moving object of the image sequence in the precondition of known object's moving speed and direction, if we can estimate the moving target's position in the next image then we can filter the historical position and could position in the next image and estimate the possible appear position of the moving object. Then use the template matching methods match the object in possible position area of the image, can effectively decrease the searching region. Correction the speed of the moving target can extremely improve the accuracy of the tracking and decrease the calculation time of per-frame image processing process, achieve the real-time target tracking.

## PROCESSING RESULTS AND ANALYSIS

The designed accomplish the moving object detection and tracking in the fixed background and fixed camera position situation. Here we use the template matching algorithm based on Kalman filter to track the moving object, Fig. 2 show the track result of contentious 3 frame image.

According to the result above we can conclude that by using the conventional template matching method and the template matching method based on Kalman filter algorithm we can complete the objecting tracking in image sequence. But the conventional template matching method waste the vary time in searching unneeded area in current image and need about 2 min to complete the matching in current frame image. We can improve the processing speed to 20 sec $f^{-1}$ and got the more target tracking accuracy by using the template matching method based on Kalman filter algorithm mentioned here.

## CONCLUSION

Because of the changing illumination, shake of the camera, background interference, shadow and interception between the moving object, take a great challenge to the moving object tracking. the conventional template matching method need huge calculations to cause slow processing speed and non real-time process ability. The template matching method based on Kalman filter algorithm can tracking the moving object accuracy and improve the processing speed.

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