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Research on the Moving Target Detection Algorithm of the UAV Ground Station Terminal

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Abstract. In the moving target detection algorithm, a single target detection methods are often unable to meet the actual needs, Therefore, in view of the UAV ground terminal mission requirements of the designated in reconnaissance and scanning mode, based on the traditional moving target detection algorithm, proposed an improved target detection algorithm with an improved frame difference, Gaussian mixture modeling and background subtraction combining. Through three frame difference method to preprocess the image, and then use the difference image to make Gaussian background modeling to realize the adaptive background update. After that, the frame of the video sequence and the background image of Gauss do background subtraction to achieve moving target detection and extraction, which significantly improves the detection effect. Finally through the MATLAB simulation, we achieve the desired effect of moving target detection.

Keywords: background subtraction, gaussian mixture model, moving target detection, three frame difference

1 Introduction

Now, visualization and intelligence is becoming more and more important, and moving target detection is one of the themes, it combines image processing, pattern recognition, artificial intelligence, morphology, and the advanced technology in the field of automatic control and so on, in a number of video monitoring system security and UAV reconnaissance area, the technology has good application value and research value. The purpose of moving object detection is to separate the moving object from the background, which is the basis of the recognition and tracking of the moving object in the later stage [1].

Traditional target detection algorithms are inter frame difference method, background subtraction method and optical flow method, where the inter frame difference and background difference algorithm are widely used [2-3]. But single detection algorithms are not applicable in a variety of scenarios, such as in the scene of light, the color of the factors which results in the detection results are affected by a lot of noise factors interference, so that we can’t get ideal results.

With the rapid development of intelligent video surveillance, experts and scholars at home and abroad are committed to develop a different background model, in order to reduce the impact of dynamic scenes on the background model. For example, Long and Yan proposed an adaptive smoothing algorithm, that is, in an image sequence, the pixel point is in the stable state of the longest gray value is the background pixel gray value. But if the foreground moving slowly or stationary, at this time will result in an error; Friedman and Russell put forward the image pixel gray value as three Gaussian distribution of weighted, corresponding in the foreground, background and shadow. Because of the background of the monitor is often more complex, only to single pixel using a Gaussian distribution generally can’t get good effect; Stauffer and Grimson of this algorithm was improved an adaptive Gaussian mixture background model, Gaussian model was established by the image of each pixel, and the online estimation, model updating,

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and is good to solve the illumination change, dynamic field in micro small disturbance and influence. Based on the algorithms for target detection and the UAV target reconnaissance monitoring system, on the traditional single moving target detection algorithm, we achieved the frame difference method, background difference algorithm and Gaussian mixture background modeling algorithm combination, which overcomes the shortage of the single algorithm, such as the three frame difference resolve the the gray level requirements by the background, and the improved Gauss modeling solves the speed, frame extraction time requirements and other issues which has important significance to the development of UAV ground station terminal, and its application in real time monitoring, target detection and so on [4].

2 Moving Object Detection Algorithm

2.1 Three Frame Difference

Based on the second frame difference the improved three frame difference method basic principle is to select three consecutive frames in video image sequence and the difference between two frames are calculated respectively, and then do image processing and binarization processing respectively for the difference results [5]. Finally we put each pixel point to get the binary image of logic and arithmetic, access to common part, thereby gaining the outline of moving target information. the algorithm implementation methods are as follows

Set up $I_{t-1}(x,y)$, $I_t(x,y)$, $I_{t+1}(x,y)$ are continuous three frames respectively, make $I_{t-1}(x,y)$ and $I_t(x,y)$, $I_t(x,y)$ and $I_{t+1}(x,y)$ difference respectively, then calculate the difference between two frames image represented as Eq. (1)

$$\begin{aligned} D_{(t,t-1)}(x,y) &= \left|I_t(x,y) - I_{t-1}(x,y)\right| \\ D_{(t+1,t)}(x,y) &= \left|I_{t+1}(x,y) - I_t(x,y)\right| \end{aligned} \tag{1}$$

The obtained two difference images are divided into threshold value T. the result is as Eq. (2).

$$\begin{aligned} W_{(t,t-1)}(x,y) &= \begin{cases} 1 & D_{(t,t-1)}(x,y) \ge T \\ 0 & D_{(t,t-1)}(x,y) < T \end{cases} \\ W_{(t+1,t)}(x,y) &= \begin{cases} 1 & D_{(t+1,t)}(x,y) \ge T \\ 0 & D_{(t+1,t)}(x,y) < T \end{cases} \end{aligned} \tag{2}$$

And then get the two value image to do logic and get the two value image as equation (3).

$$W_t(x,y) = \begin{cases} 1 & W_{(t,t-1)}(x,y) \cap W_{(t+1,t)}(x,y) = 1 \\ 0 & W_{(t,t-1)}(x,y) \cap W_{(t+1,t)}(x,y) \ne 1 \end{cases} \tag{3}$$

After that, we process the two valued image by the open and closed operations in morphology, which is used to remove the noise in the image and the void in the moving object. The three frame difference algorithm flow chart is shown in Fig. 1.

Relative to the second frame difference, three frame difference overcome the hole in the second frame difference phenomenon to some extent, make the moving target positioning more accurate than second frame difference, the algorithm implementation methods are as follows [6].

The interframe difference method has very strong adaptability, but interframe difference method for the choice of the frame is very demanding, On one hand the fast moving objects need to select a very small time interval, if the time interval is too long will result in no overlap region of moving object in two adjacent frames as two moving objects; on the other hand, slow-moving objects need to select a larger time interval. If the time interval is too short, will lead to the moving object in two adjacent frames are almost coincident with, so as not to detect motion regions. In addition, the moving target area between adjacent frames can be overlapped, and the extracted moving target area may not be complete.

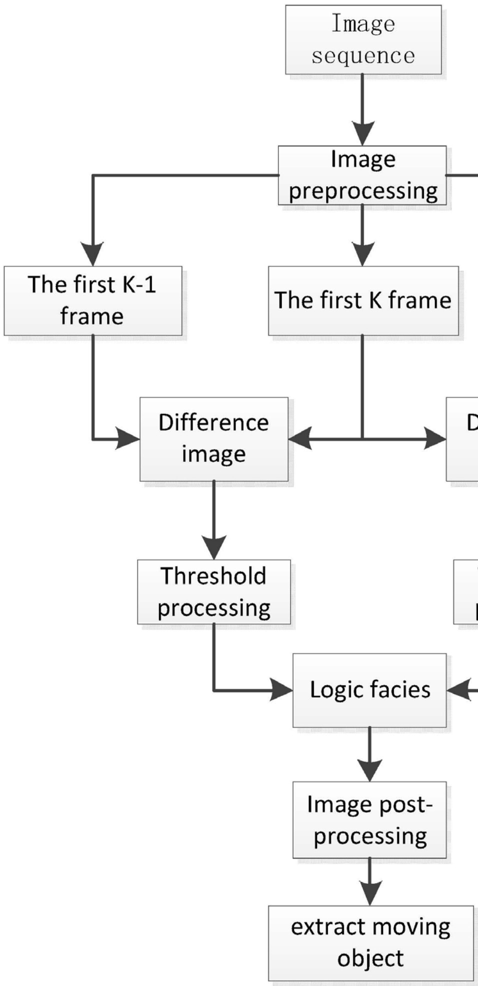


Fig. 1. Flow chart of three frame difference algorithm

2.2 Background Subtraction

Background subtraction method is the most commonly used algorithm for moving object detection. Its basic idea is first to establish background model, then the current frame image with the background model subtraction, if the threshold of pixel value is greater than a threshold, then determine the pixel region of the image in the position of the moving foreground region and vice versa for the regional background.

$$D_t(x,y) = |X_t(x,y) - B_t(x,y)| \quad \textbf{(4)}$$

$$R_t(x,y) = \begin{cases} 1, & D_t(x,y) > T \\ 0, & D_t(x,y) \le T \end{cases} \quad \textbf{(5)}$$

In the Eq. (4,5), $X_t(x,y)$ is the current frame image, $B_t(x,y)$ is the background image, and $D_t(x,y)$ is the difference image, and T is the threshold, 1 on behalf of the motion region, with 0 representing the background area, by the formula 4,5 can be seen, to establish a suitable background model for moving objects detection is very important. The background difference principle flow chart is shown in Fig. 2.

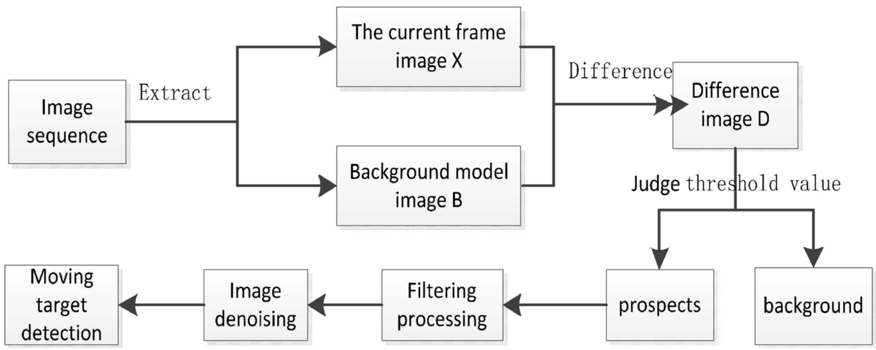


Fig. 2. The background difference principle flow chart

The key of background difference is the background modeling. The background of the algorithm is based on the background of the module. Background update is designed to make the background image of the background image of the current detection of the background image is infinitely close to the background image. Background models are often affected by external factors, such as changes in light. The fuzzy phenomenon of the background of the model is easily caused.

Moving target detection application is divided into fixed camera and camera movement two scenes, for the motion of a camera setting is a complex scene, commonly used optical flow method to detect, and optical flow method computational complexity, limited application scenes, popularization and application; the scenes with a fixed camera, scene background change relatively slow, the mixed Gaussian background modeling algorithm.

3 Improved Moving Target Detection Algorithm

This design implements an improved background difference method, the algorithm based on three frame difference and background difference method. Among them, the background updating module using mixture Gaussian background modeling, the background image and the background image of the current detection environment infinitely close to, and eventually realize the detection of moving target in a regional reconnaissance.

3.1 Mixture Gaussian Background Modeling

Mixed Gauss model is one of the common methods of background modeling. It uses K(3~5) Gaussian model to the characteristics of each pixel in the image representation, after obtaining a new image frame update Gaussian mixture model, and then matching each pixel in the current image and the Gaussian mixture model, if success is judged the background, otherwise it is in front of the scenic spots [7-8].

3.1.1 The Establishment of Gauss Models

For pixel (x_0, y_0), the $x_t = [r_t, g_t, b_t]^T$ at t time is the background probability as equation (6):

$$P(x_t) = \sum_{i=1}^{k} \omega_{i,t} \eta(x_t, \mu_{i,t}, \sum{}_{i,t}) \quad \textbf{(6)}$$

Satisfy $\sum{}_{i,t} = \sigma_i^2 I$, In the equation (4), K is the number of Gauss model, $\omega_{i,t}$ is the weight of the Gauss distribution, $\eta(X_t, \mu_{i,t}, \sum{}_{i,t})$ is the first i Gauss distribution, K Gauss distribution is always in accordance $\rho_{i,t} = \dfrac{\omega_{i,t}}{\sigma_i}$ with the priority from high to low sort.

3.1.2 Matching and Updating

The new observation x_i is matched with the K Gauss distribution of the priority $\rho_{i,t}$ level from high to low, λ is the threshold. For each pixel, if it meet the matching conditions, and then $i < k$, the current Gauss model is not enough, then in the background of the pixel model to add a Gauss model; but if $i = k$,then the new Gauss distribution is used to replace the Gauss distribution with the lowest priority in the Gauss model. The new Gauss distribution takes the x_i as the mean, and the initial one is a large variance. By constantly updating the background image, the background model can be used to detect moving objects.

Among them, the Gauss distribution weight updating as $\omega_{i,t} = (1-\alpha)\omega_{i,t-1} + \alpha M_{i,t}$, matching distribution $M_{i,t} = 1$, the rest of the distribution $M_{i,t} = 0$, Matching Gaussian distribution of mean and variance are updated, update as equation (7).

$$\begin{aligned} \mu_{i,t} &= (1-\beta)\mu_{i,t-1} + \beta x_t \\ \sigma_{i,t}^2 &= (1-\beta)\sigma_{i,t-1}^2 + \beta(x_t - \mu_{i,t-1})^2 \end{aligned} \quad \textbf{(7)}$$

In the equation (7), β is the learning rate. Of course, for the Gaussian model mismatch, we should accord to the weight formula to reduce its weight, and after each update weights to weight a normalized processing, to ensure that the weight of the sum of 1.

3.1.3 Generating Background Model

Re - to each of the Gauss model according to priority $\rho_{i,t}$ from large to small, Since the Gauss distribution is most likely to describe the stable background process located at the top of the sequence, so take the former B Gauss distribution according to the weight of the joint formation of the background, as equation (8~9). If T selects a small value, the background is usually described by a Gauss distribution; if the T selects a larger value, the background is mixed by a number of distributions.

$$x_{bg} = \sum_{i=1}^{B} \omega_{k,t}\mu_{i,t} \quad \textbf{(8)}$$

$$B = \arg\min_{b}(\omega_k > T) \quad \textbf{(9)}$$

The pixel value of a and the former B Gauss distribution to match, if you meet the matching conditions, the pixel point for the background, otherwise the former spot. Although the distribution of the model is unchanged, the model can be used to ensure that the model can extract and update the background according to the change of the actual environment. The process of background modeling and updating of video sequence images is shown in the Fig. 3.

When a large slow moving object monitoring environment, if the moving objects in the whole pixel value is basically the same, such as long waiting for the bus moving target, when the speed of moving target is relatively slow, due to specific areas of the background foreground pixels value remains unchanged, in updating model, when objects are likely to blend into the background, so that it was impossible to detect moving object. Therefore, it is very important to update the background model in the mixed Gauss model. The traditional way of updating is to update the image of all pixels in a unified way, do not distinguish between the moving target area and the background area. This will have some problems. On the one hand, slow moving objects because and model matching pixel number increases gradually and weight increase into the background, lead to detection of moving targets, on the other hand, due to the non moving object from static to moving objects, resulting in the detection process is still moving target and need to wait behind the model convergence can be eliminated, but the convergence speed of the model is relatively slow need long time to blend into the background. In view of the above problems, an improved parameter updating method is proposed as follows.

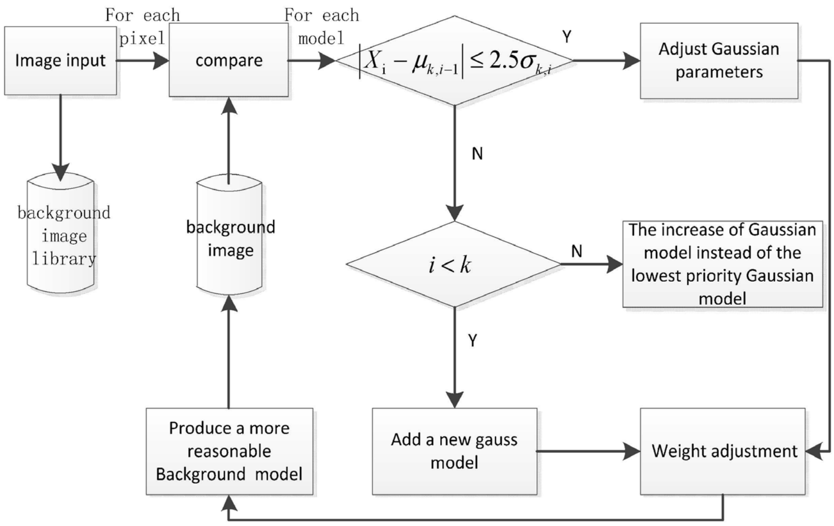


Fig. 3. Gaussian mixture background modeling and update flow chart

The whole video image is divided into two categories, one is the moving target area, the other is the background area, we use different ways to solve these two areas to solve the problem above. Due to the relatively slow speed to update the background model, but regional background in a short period of time occurred the possibility of change is relatively small. Therefore, this paper puts forward in the background update according to the feedback information, every four frames of a background model are iteratively updated, but for the foreground region per frame are updated, in order to improve the efficiency of the prospect of moving target detection stage.

In order to improve the updating of the parameters of the Gauss model, we introduce the parameter ck, which represents the moving regions in image pixel and moving target Gaussian model matching the effective pixel count of maximum value, and K represents the K moving objects. ck update method is put into the moving region matching pixel count plus 1and the movement outside of the area of the pixel matching counts recovered to 0. ck is related to a moving object velocity, when ck is large, indicating that the speed of the object motion is slow or by motion is transferred into a static; if ck is relatively small is relatively fast moving objects, if ck is moving objects may be incorporated into the background.

- When $c_k < T_1$, it indicates that the moving speed is relatively fast, and the moving object can not be integrated into the background.
- When $T <_1 c_k < T_2$, it indicates a slow moving object.
- When $c_k > T_2$, it is possible to move from a motion to a stationary object, which needs to be further verified.

When the moving object is static, moving frame difference result is no moving objects or only a few foreground pixels. At this time the Gaussian model of motion detection regions of foreground pixels statistics, statistics of a foreground pixel number M, frame difference statistical methods in the area of foreground points for N, then we according to the equation (10) to judge whether a stationary object.

$$T = \frac{N}{M} \quad \textbf{(10)}$$

The setting threshold value is T, and the T value is set by repeated experiments and experience value, that is, when the T is less than the threshold value, it is considered that the moving object becomes a stationary state.

Updating the parameters in the area of motion:

$$\omega_{i,t} = \frac{1}{\omega_k}(1-\alpha)\omega_{i,t-1} + \frac{1}{C_k}\alpha M_{i,t} \quad \textbf{(11)}$$

The weight of the region where the moving object is located is updated by formula (11), where the variance, the mean and the updating mode of the background area are not adjusted.

Due to the Gaussian mixture modeling using the weights to determine the pixel is foreground or background, so only for updating the weights adjust from the type can be seen more and slow down the speed of a moving object c_k value, then the weights, which can prevent the slow moving objects into the background.

3.2 Implementation of Improved Algorithm

The improved moving target detection algorithm includes image preprocessing, morphological processing, inter frame difference algorithm, mixed Gauss background modeling, background subtraction algorithm, and so on. The implementation steps of this algorithm are as follows:

- Make sequence of video frames from the camera to obtain pre-processing, including elimination of noise, binarization processing.
- The With improvement of three frame difference method to get the adjacent frames do two difference respectively.
- Make the differential results obtained by three frame difference do a Gaussian mixture model and initialized.
- To determine whether the results of the current model and the establishment of a certain time Gauss background model matching, if the match is assigned to 0 and set as the initial point, does not match the updated Gauss background model.
- The frame of the video sequence and a Gaussian mixture background model difference, then the difference results of each pixel a Gaussian mixture model and initialization, generally take priority of the larger number of Gaussian distributed synthetic background model.

Through the judgment, and disposition of Gaussian mixture model obtained binary image with a moving target, do logic "and" with the containing target motion between two adjacent binary image, finally, do the necessary after treatment, including morphological filtering and region growing to remove image noise and fill holes, in order to obtain the accurate moving objects. The overall flow chart of the algorithm is shown in Fig. 4.

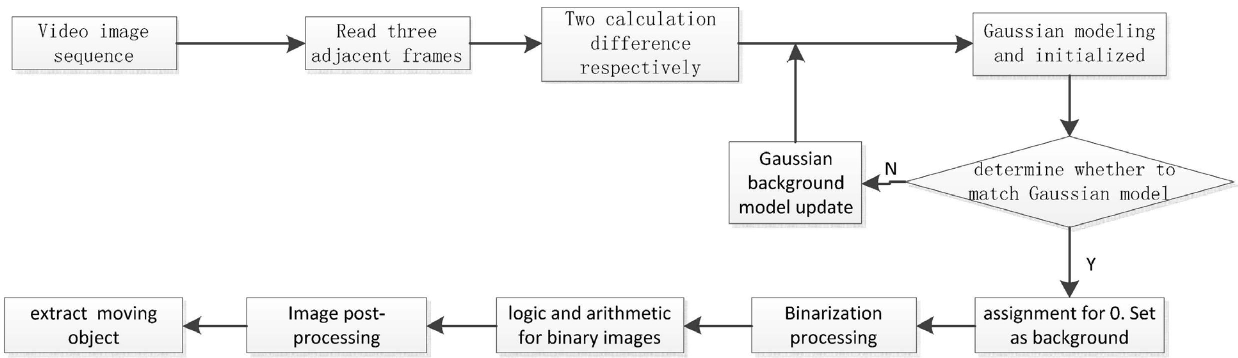


Fig. 4. Flow chart of improved moving target detection algorithm

Through the mixture Gaussian model after won the sports scene background, the current image frame and the background image subtraction can obtain the area of moving object, but if the gray level of moving targets and the background image gray scale are nearly, the background subtraction cannot complete detect movement information, where we can detect the moving background through three frame difference method that subtraction was not detected in the region. Getting the logic or the movement of the area combining two methods, you can get a complete movement area.

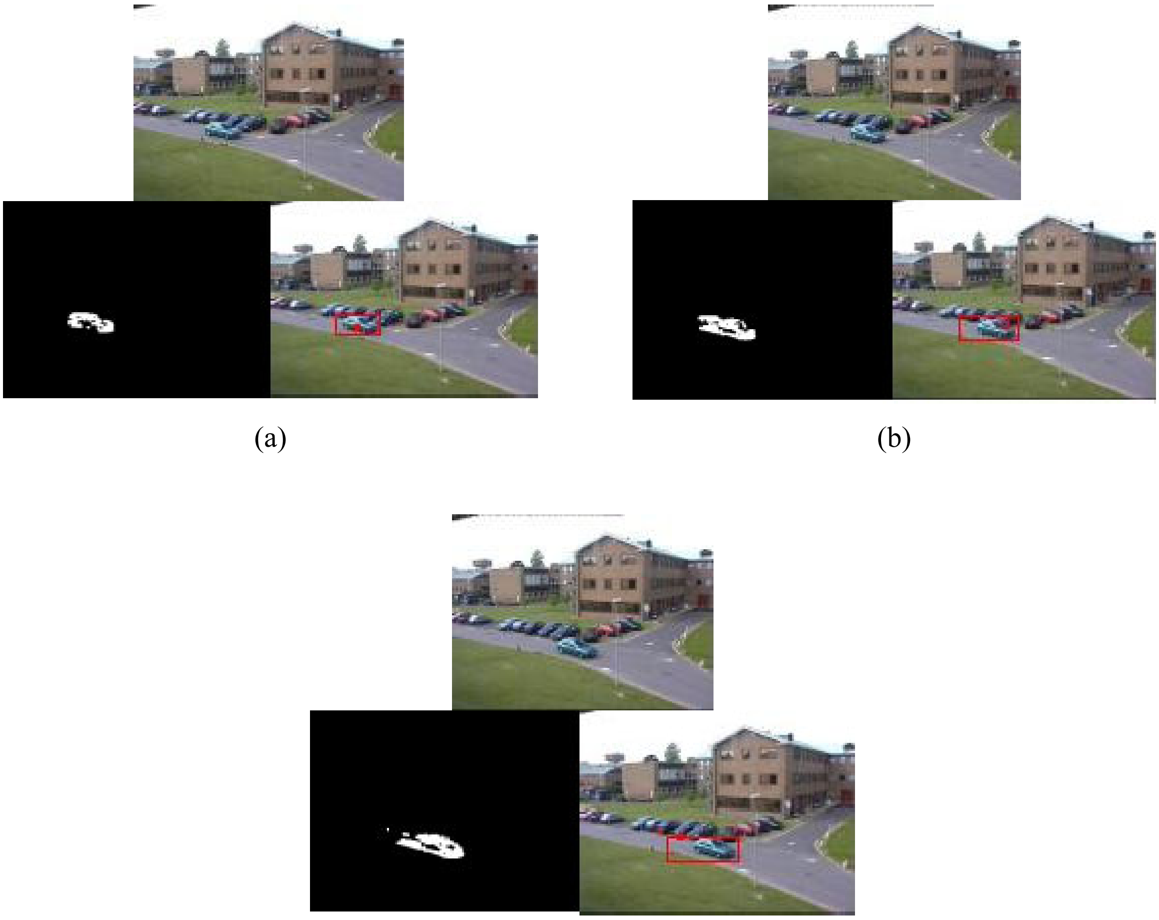
After for moving target detection, moving target motion regions, however, to learn more moving target information, you need to on moving object classification, to determine the movement trajectory, after getting the information, in order to further describe the behavior of moving object

4 Simulation and Experimental Analysis

In order to test the proposed algorithm is effective, according to the above theory, we selected the Windows 7 system, and do several groups of experiment using MATLAB simulation to verify the feasibility of the algorithm. In order to better applied to the unmanned aerial vehicle (UAV) terminal for point scanning and target detection task, under the existing experimental conditions, we detect the single and multiple moving targets under the fixed camera respectively. In the experiment, the T1 value is 15, the T2 value is 40, and the threshold value T is set to 0.65.

4.1 Single Moving Target Detection

Under the camera fixed, choose one near a residential moment cars for moving target detection, and realize the real-time tracking of targets. From the simulation results better several groups of images, moving target detection results are shown in Fig. 5.

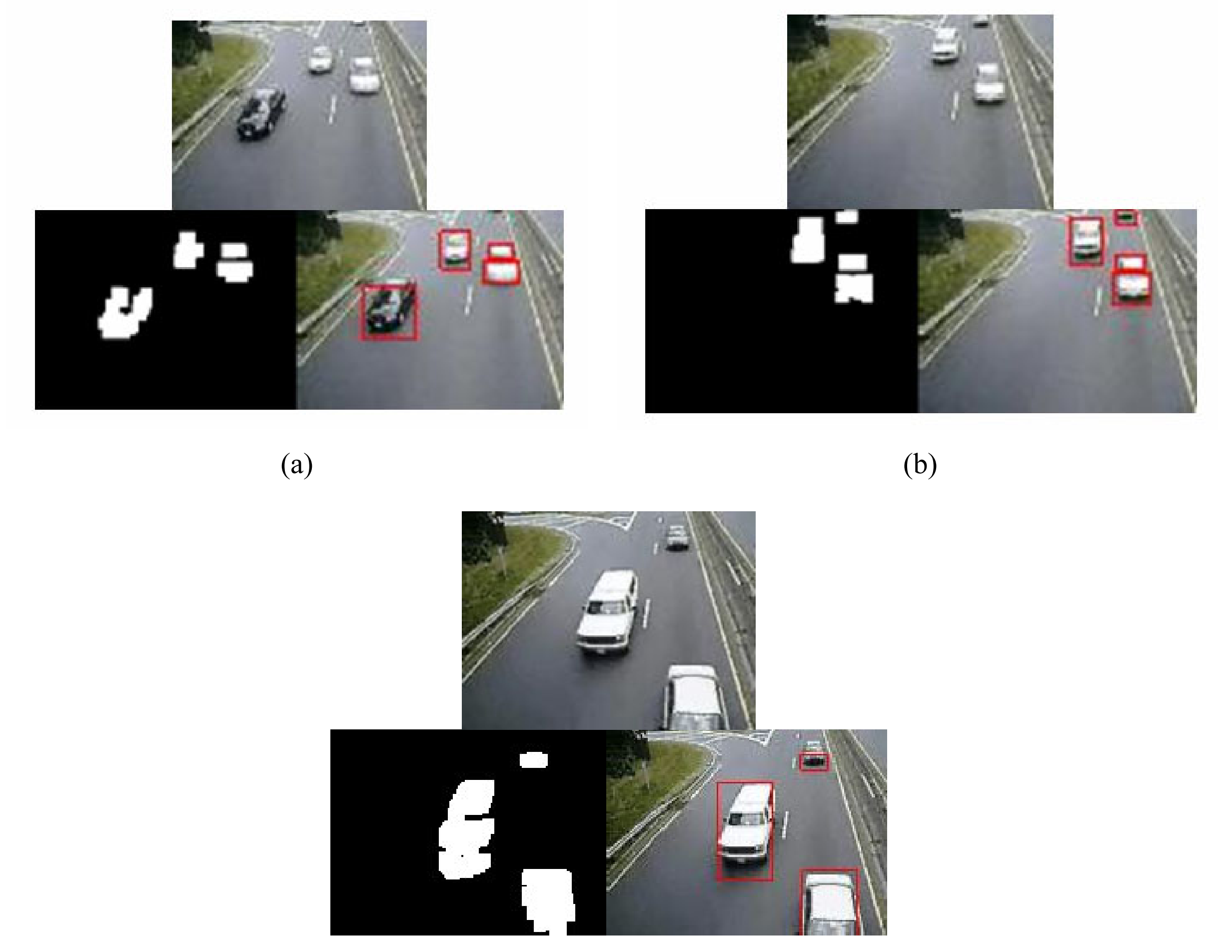


(a) (b) (c)

Fig. 5. Flow chart of improved moving target detection algorithm

In single moving target detection results, selected the sixth frame, twelfth frame and the twentieth frame detection effect, the results correspond of Fig. 5(a), (b), (c) three groups of images, and Each group of three pictures corresponding to the current frame image, the target detection results and tracking effect chart. By improving the algorithm for the simulation of the single moving target detection effect, we can found that the improved algorithm of detection effect is clear and can effectively realize the tracking of moving targets.

In the actual video surveillance scenes, a number of moving objects are often appear, which often need to track multiple moving objects at the same time. How to make continuous tracking of multiple moving objects accurately and effectively is a difficult problem in the intelligent video surveillance system. So under the same experimental equipment, we choose one of the routes of vehicle detection in video, through traffic detection, to verify the improved algorithm of moving target detection and tracking effect. The renderings are shown in Fig. 6.



(a) (b)

(c)

Fig. 6. Multiple moving target detection

Also, we select the three groups of images with better effect, the results correspond of Fig. 6 (a), (b), (c) three groups of images, and each group of three pictures corresponding to the current frame image, the target detection results and tracking effect chart. By the detection effect it can be seen that improved algorithm about the detection of multiple moving targets recognition have no obvious effects of the single target, but also has practical value, which will be good for the UAV ground station late point scanning and identifying movement.

5 Conclusion

Motion detection technology is the foundation and key technology of the intelligent monitoring system, and its performance directly affects the success or failure of the system. The design on the understanding of the moving target detection, introduces the traditional frame difference moving target detection algorithm. Based on this, fusion three frame difference, mixed Gaussian background modeling and background difference designed an improved target detection algorithm. This paper mainly introduces the Gauss model and the mixed Gauss background modeling technology, where analyzed the GMM in detail, and also analyzed the advantages and disadvantages, and improved the GMM algorithm on the basis of the original algorithm. We uses Gaussian mixture modeling to realize the adaptive background update, combining the three frame difference pre- processing to overcome the shortcomings of points in a similar gray where it cannot be accurately detected target with background difference. Finally realizes the moving target detection, simple calculation and detection effect is obvious, and also achieve the goal of single and multiple objective of real-time detection and tracking.

Motion target detection and tracking is the most basic and key technology in video surveillance and object reconnaissance, which has important applications in human computer interaction, entertainment, and industrial control. Due to the complexity and uncertainty of the practical application environment, the algorithm has some problems that need to be solved. For example, in the simulation experiment, we detect and track are in the condition of camera fixed, so the mobile terminal needs to be further improved.

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