Moving Object Detection Methods When Camera Moving

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Abstract

In the process of movement target detection, the moving of camera can lead to moving target and background’s corresponding movement in image sequences, which bring a big problem in moving targets detection the problem. Therefore, two methods have been studied: one is moving target detection methods based on the dynamic motion compensation. In this method, first to build the background of the global movement modeling, with robust estimation method to estimate movement parameters and motion compensation, thus static the dynamic background, then follow-up process used to detect the moving object; The second method is dynamic background moving target detection methods based on the YCbCr color space. This method build YCbCr color model which is superior to other color model, based on the color model establish color histogram, and do image segmentation and subsequent processing, testing the moving targets. Experimental results show that the two methods can better accurately detect the target object contour, the accuracy of second method was significantly higher than the first method and real time better.

Keywords: Motion compensation, Three frame difference method, YCbCr color model

1. Introduction

With the computer operation speed increased year by year, machine vision has been continuously applied in many new fields, such as target recognition used to identify different tested object, the shape of the products and size detection [1], and the safety monitoring, etc. The importance of exercise target detection show. Moving targets detection in weapon system, aerospace, modern military domain has wide application. In the modern military combat, rapid information acquisition and processing power is the key to winning the battle. Therefore, the target real-time detection and tracking is also makes it necessary to identify the prerequisite. Target detection [2-3] has a broad prospect of application and potential economic value. However, due to the diversity and complexity of the scenery and the uncertainty of the trajectory, there are still many problems remain to be solved in practical application. Therefore, the moving targets detection methods have realistic significance and application value.

Compared with static background moving targets detection method, there exist a complex relative motion between goal and the camera between the in the moving targets detection process under dynamic background [4-5] since most static background’s moving target detection method is not applicable to dynamic background. The commonly used dynamic moving object detection methods can be roughly divided into two kinds: one kind is based on global motion compensation method; the other kind is based on the method of optical flow [6].

With a lot of calculation, it is very hard for light flow to meet real time requirement, not suitable for real-time processing. Therefore, this article, moving object detection process based on the global motion compensation methods is adapted under the dynamic background. The basic ideas is that firstly established background motion parameter model [7], and then calculates the background of the motion parameters, with the estimated parameters of movement to do background compensation, converting the dynamic background into a static background, and then using the three frame difference method [8] to detect moving target. But this method has a large calculation. In order to solve this problem, the YCbCr color space [9] is applied and a moving target detection method is presented in dynamic background especially in the camera moving condition in this paper. The simulation results show that the algorithm is suitable and valid.
2. Moving target detection methods based on the dynamic motion compensation

Relative to the moving target detection method in static background, the moving target detection methods in dynamic background based on motion compensation firstly to do global background movement compensation, staticize the dynamic background, and then conduct the follow-up processing. Target detection methods based on the dynamic motion compensation process shown in figure 1.

![Diagram of target detection methods based on the dynamic motion compensation](image)

**Figure 1.** Target Detection Methods Based on the Dynamic Motion Compensation Process

When the camera move, the coordinate location between two frames in the images of objects in the camera scene meet some corresponding relation, which can be shown in global motion parameters model, the different mode of motion of camera have different movement parameter model. Combined with the actual conditions of the camera movement, this article chooses affine movement parameter model as a background motion parameter model. Parameter model contains six parameters; the mathematical formula is as follows:

$$
\begin{bmatrix}
  x_k \\
  y_k 
\end{bmatrix} = \lambda
\begin{bmatrix}
  \cos \alpha & -\sin \alpha \\
  \sin \alpha & \cos \alpha 
\end{bmatrix}
\begin{bmatrix}
  x_{k-1} \\
  y_{k-1} 
\end{bmatrix} +
\begin{bmatrix}
  e \\
  f 
\end{bmatrix}
$$

$$
= \begin{bmatrix}
  a & b \\
  c & d 
\end{bmatrix}
\begin{bmatrix}
  x_{k-1} \\
  y_{k-1} 
\end{bmatrix} +
\begin{bmatrix}
  e \\
  f 
\end{bmatrix}
$$

(1)

Among them, $\lambda$ is scaling movement parameter, $\alpha$ for rotation Angle, $(e, f)$ for direction of translation exercise parameters along the x axis and y axis.

Based on the affine model, the feature point extraction method adapts Harris which belongs to corner detection algorithm. The minimum amount calculation of the Absolute deviation
standards is used to feature matching after analysis and comparison with the search strategy - optimal diamond search method.

After feature extraction and matching method, the feature points of reference frame and the current frame is got. According to the affine movement parameter model, can get equations as below:

\[
\begin{bmatrix}
x_{k-1}^{(i)} & y_{k-1}^{(i)} & 0 & 0 & 1 & 0 \\
0 & 0 & x_{k-1}^{(i)} & y_{k-1}^{(i)} & 0 & 1 \\
\vdots & \vdots & \vdots & \vdots & \vdots & \vdots \\
x_{k-1}^{(n)} & y_{k-1}^{(n)} & 0 & 0 & 1 & 0 \\
0 & 0 & x_{k-1}^{(n)} & y_{k-1}^{(n)} & 0 & 1 \\
\end{bmatrix}
\begin{bmatrix}
a \\
b \\
c \\
d \\
e \\
f \\
\end{bmatrix}
= 
\begin{bmatrix}
x_{k-1}^{(1)} \\
x_{k-1}^{(1)} \\
\vdots \\
x_{k-1}^{(n)} \\
x_{k-1}^{(n)} \\
\end{bmatrix}
\]

(2)

Among them, \((x_{k-1}^{(i)}, y_{k-1}^{(i)})(i = 1 \cdots n)\) for the ith feature point pixel coordinates in reference frame, \((x_{k-1}^{(i)}, y_{k-1}^{(i)})\) to the corresponding pixel coordinate between current frames, and \((a, b, c, d, e, f)\) is the global movement between the unknown parameters of adjacent reference frame which need of solving.

With the least square method, getting the approximate solution of the movement parameters, but the exterior points will affect the overall movement parameter precision. This paper uses a statistical robust analysis wipe off the exterior points. When Global motion compensation, for reference frame of each pixel \((x_{k-1}^{(i)}, y_{k-1}^{(i)})\), can get the global motion parameters, then according to the affine movement model, can be compensated for the new coordinates. And in matching process, the calculated coordinates \((\tilde{x}_{k-1}, \tilde{y}_{k-1})\) are not necessarily integer, can’t get pixels. Therefore using the bilinear interpolation to adjust and optimize.

3. Moving target detection methods Based on YCbCr color space

In computer visual object recognition, the extraction and texture and shape characteristics’ extraction usually used in object recognition. color recognition in object recognition plays a very important role, mainly because of the color information based on object recognition has the following advantages: (1) in the color image, pixel is the basic unit of the image, pixel contains color information, pixel color is the most primitive input information, and other features such as texture, shape, etc are from color characteristics analysis of many pixels; (2) color has a translation, rotation, zooming invariance, has little dependence of the size and perspective and the direction of the image itself, has the very good robustness.

The target detection method Based on the dynamic motion compensation process is complicated, affecting the improvement of the system. According to a priori information of the moving objects to be detected, a moving target detection methods based on YCbCr color space in dynamic background, this method is simple and easy to realize. Moving target detection methods based on YCbCr color space in dynamic background is shown in figure 2. First, established the image color model; then based on color model establish color histogram, and then through the color histogram do image segmentation and image segmentation image; at last do further treatment: image denoising, morphology processing, connected component labeling.
3.1 The mode of color space

In different fields of application and different conditions have different color space model, such as the HSI color space, RGB color space, YCbCr color space, HSV color model, CMYK color space, etc. the commonly used as follows.

RGB (Red, Green, Blue) color space is a color standard in industry, it is a development and adding mixed color space based on three colors theory. RGB color model including all colors—human vision almost can perception which is one of the most widely used color system, currently.

HSI color model is put forward in 1915 by the color experts H. A. Munseu, and it reflects the way of color perception in visual perception system, use three basic characteristic features — tonal, saturation and the intensity to perceive color. HSI HSL, HSV color model are belonging to the same kind of color model.

In YCbCr color model, Y is brightness component, Cb is blue chromaticity component, Cr is red chromaticity component. The human eye is more sensitive to video brightness components. So can reduce weight chroma through sampling reduce data quantity, and the human eye can't feel video of change. The linear transformation relation of RGB color model to YCbCr color model is:

\[
\begin{bmatrix}
Y \\
Cb \\
Cr
\end{bmatrix} = \begin{bmatrix}
65.738 & 129.057 & 25.064 \\
-37.945 & -74.494 & 112.439 \\
\end{bmatrix} \begin{bmatrix}
R \\
G \\
B
\end{bmatrix} + \begin{bmatrix}
16 \\
128 \\
128
\end{bmatrix}
\]

3.2 The selection of color space model

Through the comparison of the three kinds of space characteristics, YCbCr color model is choose for target detection. The main reason is that YCbCr color model has the following advantages:
In the YCbCr color model, Cb and Cr is color information, they are independent of brightness information Y, and they are independent of each other, this is one of the important advantages of YCbCr color model. Usually environment light is constant change, if the color information are independent of brightness information, it can greatly improve the robustness of the detection algorithm.

(2) YCbCr color model has the similar composition principle with human visual perception process.

(3) YCbCr color model is widely used in images, video compression coding, choosing this space can directly use the data decoding in practical application, reducing the amount of computation;

(4) The transformation from RGB format to YCbCr format is a linear process with the high efficiency calculation.

4. Processing steps

The processing steps of moving target detection methods based on the dynamic motion compensation including: three frame difference method, image segmentation, image de-noising, morphology processing and connectivity analysis and mark; follow-up process of moving target detection methods based on YCbCr color space including: image denoising, morphology processes, connected component labeling.

Three frame difference method is the improvement of continuous frame difference method. Frame differential method using the gray level difference of two frames of adjacent images to extract the moving object information, so as to achieve the target area. Due to the problems continuous frame difference method has, three frame difference method is adapted. Assuming the differences image of \( (k + 1) \) frame image and the k-1 frame image is

\[
D_{k,k+1}(x,y)
\]

then the three frame difference method and can be expressed as:

\[
I_k = D_{k-1,k}(x,y) \cap D_{k,k+1}(x,y)
\]  

(4)

Image segmentation method mainly uses the image threshold segmentation method which can separate the target area from the difference image. After the image segmentation, there are still many pixels in wrongly, for motion detection is noise, so image de-noising is necessary. Usually, in time-space domain, using templates and median filtering to do smooth deal. Median filter can effectively remove the noise, and can protect the outline of image boundary—make its constant fuzzy. Therefore median filtering is used to deal with the noise.

After image binarylization, there still has a lot of small holes and isolated small point in the target area of the difference image, and some fracture lines of the outline. These problems can be solved with mathematical morphological image processing techniques. First through the corrosion operation eliminate noise and corrode tiny isolated point connected, and then through the expansion operation fill holes and the bridge crack.

The traditional connected components labeling algorithm has two phases: the first stage is scanning the whole image, then do connected components labeling through the comparison of each pixel neighborhood, and create equivalent mark list; the second stage merge equivalent mark list, and scan images again to update the mark. Due to a need for scan images twice, the efficiency is not high, and the second stage for the programming is more complicated. Based on this, the regional growth method based on connected components labeling algorithm is put forward. The idea is that one growth process can mark the whole connected area — just scan the image once can mark out all connected area, with high efficiency calculation.

5. Experiment results and analyses

In this paper the method for the ...Two consecutive frames images including the moving target when the camera moving are shown in figure 3. The direct frame differential method results image without motion compensation is shown in figure 4. The results image for moving target extracting with motion compensation before three frame difference method is shown in
figure 5. is The segmentation results according to the Cr weight of YCbCr model and then using mathematical morphological division is shown in figure 6. The result image of Region Mark is shown in figure 7 shows and the test results of $k^{th}$ frame move goal based on YCbCr color space detection method is shown in figure.

Figure 3. Two Consecutive Frames the Target Motion Result under the Condition of the Camera Movement Directly Frame Differential Method Results.

Figure 4. The Directly Frame Differential Method Results.

Figure 5. The Result of Moving Target Detection Based on Motion Compensation

Figure 6. The Segmentation Results According to The Cr Weight of YCbCr Mode

Figure 7. The Result of the Moving Target Detection Based on YCbCr Color Space

Figure 8. The Test Results of $k^{th}$ Frame Move Goal Based on YCbCr Color Space Detection Method
From figure 4 (stationary camera) can know that under static condition, common frame
differential method, background difference method can detect moving targets, however in
dynamic background (camera movement), frame differential method completely failure. From
figure 5 can see moving targets detection methods based on the motion compensation can filter
out the background and testing the moving targets’ outline, but still have breakpoints on the
edge.

From figure 7 and figure 8, it is known that the moving targets detection methods based on
the YCbCr color space can detect out the target outline accurately. From figure 5 and figure 7, it
is known that the precision of the moving target detection method based on YCbCr color space
motion is higher than the moving target detection methods based on motion compensation. The
moving target detection based on the motion compensation method involves corner detection,
angular point matching and the motion parameters estimation; the test process is complex with
large quantity. Moving target detection method based on the YCbCr color space does not have
the complex operation and have well real-time.

6. Conclusion

What does this paper mainly study is the moving targets detection methods in dynamic background
cau sed by the camera movement. First, study the moving target detection methods based on the
dynamic motion compensation. In this method, the affine model is used to build the background of
the global movement modeling, with robust estimation method to estimate movement parameters and
motion compensation, thus static the dynamic background, then the three frame difference method is
used to detect the moving object. The experimental results showed that this method can perform well in
background motion compensation, and can test the moving targets. Finally, this paper brings forward a
dynamic background moving target detection methods based on the YCbCr color space. This method
build YCbCr color model which is superior to other color model, based on the color model establish
color histogram, and do image segmentation and subsequent processing, testing the moving targets.
The results show that the accuracy of the moving target detection method based on YCbCr color space
is better than the commonly used moving target detection method based on motion compensation, and
real-time better.

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