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A Moving Object Extraction Method for Video Based on Color Kernel Histogram

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Abstract: The traditional moving object extraction method based on Gaussian model has such defects as poor anti-noise performance, bad real-time performance. Considering these shortcomings, this paper proposed a new moving object extraction method for color video image based on regional kernel histogram. The method first proposed the idea of kernel histogram description theory which utilizing the kernel histogram to describe the area of video image. Then a new metric function for measuring the kernel histogram model is proposed. According to the features of measurement values, using the Gaussian mixture model and the metric of kernel histogram model to build the model. At last, based on this model, the moving object of video images is extracted. The experimental results show that the algorithm have a better segmentation result and have the better anti-noise and real-time performance compared with the traditional Gaussian mixture model algorithm.

Key words: Moving object extraction, color kernel histogram, video images

INTRODUCTION

Recent years, the video image is used more and more in the many areas. The video image processing technology has attracted more and more scholars' attention. However, the performance of the video image processing is not good such as the object extraction from video image. The excellent extraction of moving object is the basis of the object track, scene analysis, pattern reorganization. There are many algorithms such as moving object detection based on optical flow (Gilad, 1985), block match (Koga *et al*., 1981; Ghanbari, 1990) and statistical based (Stauffer and Grimson, 1999; Wayne Power and Schoonees, 2002). Cuevas *et al.* (2012) used the spatial and time information to extract the moving objects in a General Purpose Graphics Processing Unit (GPGPU). The new method can detect the moving object in real time with high quality in portable devices. Min *et al.* (2012) proposed a moving objects detecting method based on Markov Random Field (MRF) approach. Sabirin and Kim (2012) divided the frame of a video into blocks and then detected the moving objects with the theory of graph.

The framework of moving object extraction proposed in this paper is "background subtraction". It is a common method for real-time extraction of moving objects in image sequences. The moving objects are obtained by the subtraction between the background and the current image. It supposes that the pixels on background appear longer than moving foreground and adopts the Gaussian model to build the background. When a new image frame comes, the method updates the Gaussian mixture distribution model. If the current pixel match up to Gaussian mixture distribution model, then the pixel is the background point, otherwise, the pixel is foreground points. The method can extract the moving object effectively and the update speed of dynamic background is decided by the parameters. This method is simple and have a good segmentation effect, so it is a widely used in recent years by scholars.

MOVING OBJECT EXTRACTION METHOD FOR COLOR VIDEO BASED ON COLOR KERNEL HISTOGRAM

Suppose is the video image sequences and it can represented by:

$$F = \{f(x_i, y_j, t) | 0<t<T, i \in N, j \in N\} \tag{1}$$

where, t is time, (x_i, y_j) is the position, $f(x_i, y_j, t)$ is the pixel value at (x_i, y_j) and t.

The current statistical method supposes that one gray pixel value on the background of video follows Gaussian distribution in the time domain. That is:

$$f_b(x, y, t) \sim N(\mu(x, y), \sigma(x, y)) \tag{2}$$

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where, f_b (x, y, t) is the gray value of background pixel points at t, N (μ (x, y), σ (x, y)) is Gaussian distribution, μ (x, y) is mean value and σ (x, y) is standard deviation.

According to the result of our research, there is local correlation between the pixels in background of a video. It means that the change of background is a process of continuity and repeatability in time and space. Based on the result, this study proposed a new moving object extraction method which utilizes the kernel histogram to describe the image area. The method can reduce the time cost greatly with high performance.

Suppose V^k is the set of video frames, f^k_i is a pixel in the kth frame, so the set of pixel point f^k_i and its neighbor pixels can be represented by:

$$G^k_i = \{f^k_{i-m},..., f^k_{i-1}, f^k_i, f^k_{i+1},..., f^k_{i-+m}, |m\in N\}$$

According to the discussion above, the appearance of the moving object will not only cause the value change of the pixel f^k_i, but also cause the change of its neighbor pixels. In order to metric the value change of the pixels, the color kernel histogram is used to describe.

Definition 1: Let be the set of pixel point and its neighbor pixels and its color kernel histogram model can be represented as follows:

$$\vec{q} = [q_u]_{u=1,...,m} \quad (3)$$

$$q_u = \frac{1}{C}\sum_{i=1}^{n} \text{Kernel}(X_i - c^0)\cdot\delta(b(X_i),u) \quad (4)$$

where, $\{X_i\}$ i = 1,...,n is the set of locations of G^k, is the component number of kernel histogram, Kernel(.) is kernel function which use c^0 as its center, δ(.) is Kronecker delta function, $b(X_i)$ is mapping function of pixels to kernel histogram, C is normalization constant and ensures:

$$\sum_{u=1}^{m} q_u = 1$$

and c^0 is the location of f_i.

When the description model of color kernel histogram is used in the moving object extraction, there should be a description of the pixel set on the same position in next frame.

Suppose V^{k+1} is the set of video frames, f^{k+1}_i is a pixel in the (k+1)th frame, so the set of pixel point f^{k+1}_i and its neighbor pixels can be represented by:

$$G^{k+1}_i = \{f^{k+1}_{i-m},..., f^{k+1}_{i-1}, f^{k+1}_i, f^{k+1}_{i+1},...,f^{k+1}_{i+m}, |m\in N\}$$

The color kernel histogram model of is as follows:

$$\vec{p} = [p_u]_{u=1,...,m} \quad (5)$$

$$p_u = \frac{1}{C}\sum_{i=1}^{n} \text{Kernel}(X_i - c^0)\cdot\delta(b(X_i),u) \quad (6)$$

The color kernel histogram model descripts the pixel set and the variety of the model can represent the change of the pixel set. When the background hasn't changed $\vec{q}$ and $\vec{p}$ are equal. When background is sheltered by foreground object $\vec{q}$ and $\vec{p}$ is not equal. To compare $\vec{q}$ and $\vec{p}$, a new metric function is introduced as follows:

$$d = \sqrt{1-\rho[p,q]} \quad (7)$$

where, d is the distance measure between $\vec{q}$ and $\vec{p}$:

$$\rho[p,q] = \sum_u \sqrt{p_u q_u}$$

In video sequences, when the light is invariance and video camera is immobile, ρ = 0. When there are light change, noise or something sheltering the background area, ρ>0. With the research and analysis of the distribution of ρ on the real situation, we suppose ρ follows normal distribution, that is:

$$\rho \sim N(\mu, \delta) \quad (8)$$

where, N (μ, δ) is the normal distribution with the covariance δ and the average value μ. So the Gaussian mixture model can be used in our framework. Based on the idea of Gaussian mixture model, the updating strategy of Gaussian mixture model parameter as follows:

$$\delta_t = (1-\beta)\,\delta_{t-1} + \beta\delta_t \quad (9)$$

$$\mu_t = (1-\alpha)\,\mu_{t-1} + \alpha\mu_t \quad (10)$$

where, δ_t is the covariance, μ_t is the average value α and β are the learning rate.

THE EXPERIMENTAL RESULT AND ANALYSIS

The experiments to test the proposed algorithm are programmed in C++. The program runs on the PC with Intel P4 2.0C 512M memory. Fig. 1 is the state of Gaussian mixture model of 188th frame and the size of the G^k is 4. Figure 2 is the state of traditional Gaussian mixture model

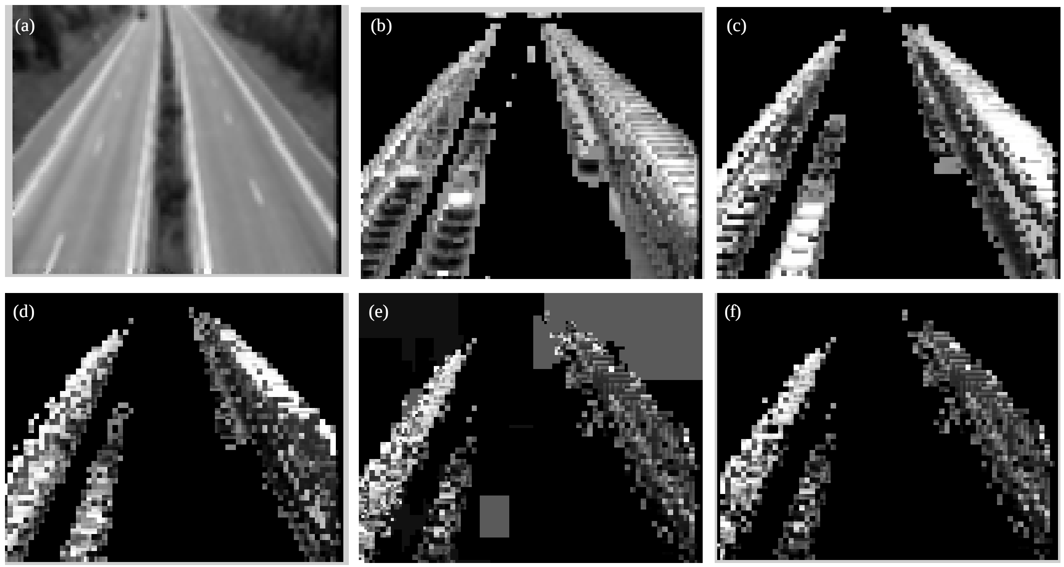

Fig. 1(a-f): The state of Gaussian mixture model of 188th frame and the size of the is 4

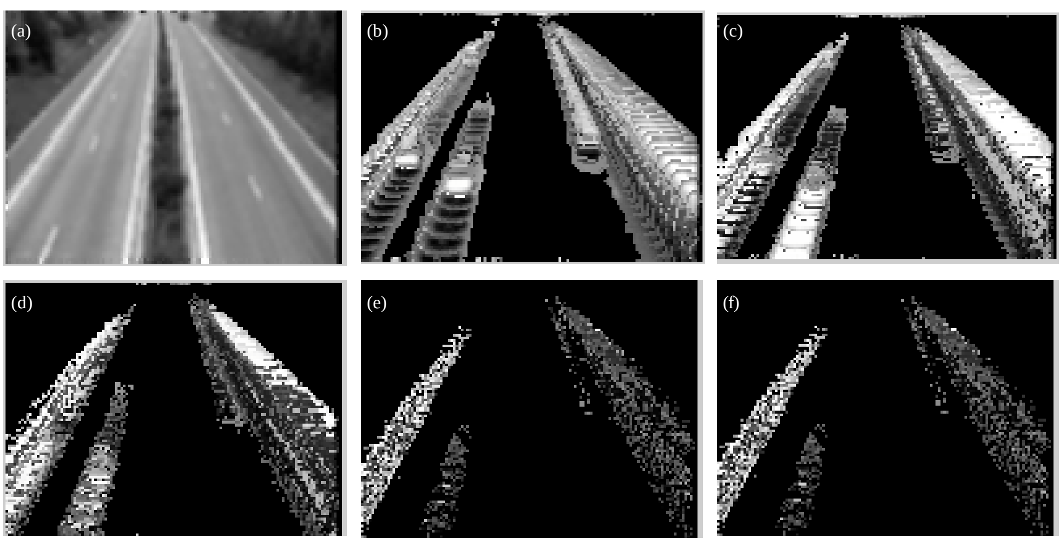

Fig. 2(a-f): The state of traditional Gaussian mixture model of 188th frame

Table 1: Average time cost of the moving object extraction in 300 frames

Algorithms	Time cost (msec)
Traditional	43
Proposed (m = 4)	26
Proposed (m = 8)	15

of 188th frame. From the two set of images, we can see that the backgrounds model they build is same, but Fig. 2 is based on single pixel, so it is more exquisite, the aperture in image 1 is more bigger and caused segmentation "holes", it can be disposed with image smooth technology. Figure 3 is the result of the extraction with the proposed method. The result shows that the moving object extracted has exact border. And there are not holes within the object.

In order to test the performance on time cost of the proposed algorithm, the time is counted. Table 1 shows the time cost of the extraction of the moving object in 300 frames.

From the Table 1, we can see that the proposed algorithm can increase efficiency of moving object

Fig. 3(a-c): The segmentation result (m = 4) with the proposed algorithm

extraction. The time cost change with the complexity of frame. As to the same video sequence, the time cost of the proposed algorithm (m = 4) is 60% of the traditional algorithm.

CONCLUSION

As the traditional moving object extraction method based on Gaussian model has such defects as poor anti-noise performance, bad real-time performance. Considering these shortcomings, this paper proposed a new moving object extraction method based on regional kernel histogram. The experimental results show that the proposed method has good performance on the time cost and accuracy of the moving object. In the next work, we will improve the efficiency of the algorithm further.

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