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Moving Shadow Removal Algorithm Based on HSV Color Space

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Abstract

In order to accurately separate a moving object from its shadow in a monitoring scene, this paper proposes a algorithm, which combines Multi-frame Average method for building background and HSV color space. First, the multi-frame average is used for setting up the background model. Second, the current frame and the background model are converted to HSV color space. In the foreground area, the values of brightness and saturation are smaller than that of the background, while the colors basically remain same. Just using these characters, the shadow is detected and eliminated. Finally, the algorithm is applied in videos with different monitoring scenes from the standard video library, such as highway, laboratory and campus, etc, to verify its effectiveness. The experiment results show that the algorithm has better accuracy, reliability and robustness than the compared algorithm.

Keywords: *the shadow detection, HSV color space, multi-frame average*

1. Introduction

In video surveillance systems, moving object detection and tracking is one of a research hot in the field of computer vision. Moving object segmented from the image sequences is the follow-up work's foundation of realizing target classification, tracking and behavior analysis, etc. Due to light and other factors, the detected moving targets often contain shadows, which cause the errors that the computer extracts and tracks the moving objects. Therefore, it is necessary to detect and analyze the images' shadows.

At present, the shadow removal methods are mainly divided into two categories: model-based and feature-based approaches. The based-model methods, which require a prior knowledge of the scene and illumination, etc, have a relatively narrow application scope. The feature-based methods need to establish the shadow characteristic region having the assumptions of lower brightness and the same chroma, and then combines with the background texture information to separate the target and shadow. Many experts and scholars have carried out in-depth research on the shadow detection and elimination of the video sequences and put forward a lot of efficient algorithms. In the literature [4], the author makes the preliminary exploration on the shadow according to the characteristics of the shadow's brightness darker and then uses the defined shadow color invariants to verify the effectiveness of the preliminary test. In the literature [5, 6], they use Gaussian Mixture Model (GMM), which to extract the background, the foreground and the shadow. GMM is only to build the model for the pixel in the image sequences, whose state has been changed, but ignores the interaction between the adjacent pixels. In addition, the parameters in the model will be got by training a large amount of data and it is difficult to implement in practice. In the literature [7], the author proposes a shadow detection algorithm based on gradient features and color. However, the gradient operator to detect is more sensitive to noise so that the shadow detection effect is affected. According to the statistical properties of the shadow and object in the YCbCr color space, Yali Deng, etc [8] set the brightness and chroma threshold to eliminate the shadow. But the robustness of the algorithm is not high, it is difficult to apply to a variety of occasions. Liu et al [9] uses the color characteristics of shadow in HSV color space to build Gaussian Mixture Model and then combines with Markov random field to eliminate the shadow. This method effect is good, but the complexity of the algorithm makes it very difficult to implement in the real-time monitoring.

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Aiming at the advantages and disadvantages of the above methods, this paper proposes a method based on the multi-frame average and HSV color space to separate and eliminate the shadow. Firstly, we use the multi-frame average method to build the background model and updates the background model in real-time. Secondly, we make the current frame and the background do corresponding operations in HSV color space. Using these computational characteristics, we deal with the pixels of the shadow and effectively eliminate the shadow. The proposed algorithm flow char is as follows:

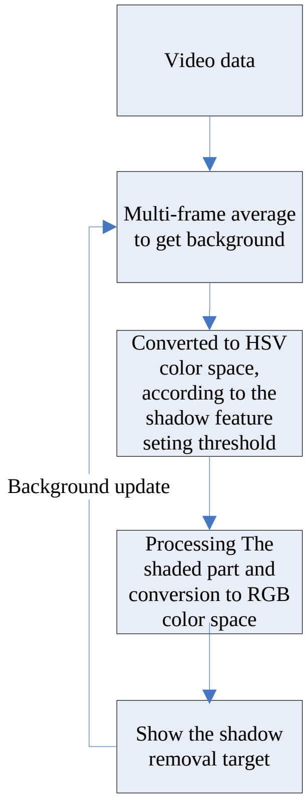

Figure 1. The Flow Chart of the Proposed Method

2. Multi-frame Average for Building Background Model

2.1. Background Extraction

There are some common background modeling methods, like median filter method, linear prediction method, Gaussian mixed method. Each of them has its advantages and disadvantages. Considering the complexity and real-time of algorithm, this paper chooses multi-frame average to set up background model. The method takes moving targets as noise, and uses accumulation average denoising to get background.

Multi-frame average is a method which takes moving targets as noise and uses accumulation average denoising. Assuming that a period of time sequence expressions of moving targets is:

$$Background(x,y)_R = \frac{1}{M}\sum_{i=1}^{M} Pixel_i(x,y)_R \quad (1)$$

$$Background(x,y)_G = \frac{1}{M}\sum_{i=1}^{M} Pixel_i(x,y)_G \quad (2)$$

$$Background(x,y)_B = \frac{1}{M}\sum_{i=1}^{M} Pixel_i(x,y)_B \quad (3)$$

$Background(x, y)_R$ indicates the values of R component in the background images. $Pixel_i(x, y)_R$ shows the values of R component in the $Pixel_i(x, y)_R$ of i^{th} frame sequence images. The rest of the G, B component is in the same way. M expresses the total number of frames in a period of time. The method model is simple, convenient calculation, can satisfy the real-time requirements in embedded development. In practice, the background image is better when the number of frame M increase, but it also takes up more system resources. So how to balance the numbers of frames and background quality is a problem to be solved. It is found by experiments that the effect is good when M is around 100. The quality of background image decreases obviously when M is below 60, while it takes up too many system resources when M is more than 150. M is 90 in the article.

2.2. Background Model Update

The paper mainly studies the scene of fixed camera. So the background interference can be roughly divided into the changes of illumination **i**ntensity, objects in the background shift out the background, and moving objects blend into background static. In the first case, photographic materials were added on the camera and threshold was set. Recording the illumination intensity after getting the background, background updates when the intensity change is more than the threshold. For the second case, when the background is completed, sample the input video frames in the period time (assuming one minute), and assume that sampling a frame per second. Make difference between sampling video frames and background frames. In the 60 frames difference frames, the recurring rate of a region higher than a threshold, we are needed to update the background.

3. Shadow Removing Algorithms

3.1. The Basis of the Algorithm Theoretic

The image detecting usually requires a particular color space. The description of the color space should match the characteristics of human visual perception and simplify process image. The RGB color space is a non-uniform color space. It is not conducive to the color image segmentation. The HSV color space is a uniform color space, it is not only illustrates how the human eye visual observation the color, but also suitable for image processing.

It is not only reaction the human eye visual observation of the color, but also suitable for image processing. In the HSV color space: V component (luminance) has nothing to do with color information; H component (hue) and S component (saturation) is closely linked with the color mode of people’s feeling. Compared with the RGB color space, correlation between the three components in the HSV color space will be much smaller. It can detect the shadow more accurately. The theoretical basis to remove the shadow is that brightness and saturation shade are darker than that in the background, but color remains unchanged, when converted to the HSV color space.

3.2. The Concrete Realization of the Algorithm

Firstly, we convert the background and the current frame to the HSV color space. Secondly, according to the brightness and saturation of the shade darker than the background, we obtain the following formula to determine whether the pixel is shaded point.

$$Pixel(x, y) = \begin{cases} 1, \alpha_V \le \dfrac{I_V(x, y)}{B_V(x, y)} \le \beta_V \cap \\ (I_S(x, y) - B_S(x, y)) \le \gamma_S \\ \cap | I_H(x, y) - B_H(x, y) | \le \gamma_H \\ 0, else \end{cases} \quad (4)$$

$I_V(x, y)$, $I_S(x, y)$, $I_H(x, y)$ and $B_V(x, y)$, $B_S(x, y)$, $B_H(x, y)$ denote the current frame V,S,H component value and background frame V, S, H component value. Parameters $0 \le \alpha_V < \beta_V \le 1$, the value of α_V according to the intensity of the shadow, the shadow is stronger, the greater luminance contrast and α_V more less. β_V is mainly used to suppress noise. The selection of γ_S, γ_H need to debug. In (4) the $Pixel(x,y)=1$, means that the point is shadow point, the processing method is replaced with the background point,

$$I_V(x,y) = B_V(x,y) \tag{5}$$

$$I_H(x,y) = B_H(x,y) \tag{6}$$

$$I_S(x,y) = B_S(x,y) \tag{7}$$

On (4) the $Pixel(x,y)=0$ mean that this point is moving target, we do not have to do processing.

4. Simulation Results

In this paper, using MATLAB R2012b for algorithm simulation, the object as the highway, laboratories, campus scene in the standard test.

4.1. Simulation Results of the Highway Scene

In this paper, the background reconstruction of highway as shown in Figure 2, this figure is the average figure of 90 frames, which the resolution is 360×240. Figure 3 is the method in reference [1]. It can be seen that the proposed method is simpler and more effective.

Figure 2. Highway Background Image of the Proposed Algorithm

Figure 3. Highway Background Image of Reference [1]

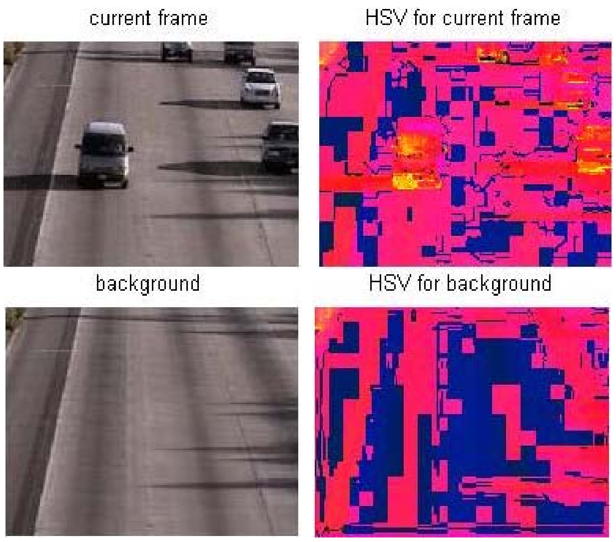

Figure 4. The Conversion Algorithm of Color Space

Figure 4 is the color space conversion chart. Highway shadow removal effect is shown in Figure 5. In this section of the video, intensity of illumination is great and the shadow brightness is small, so $\alpha_V = 0.2, \beta_V = 1, \gamma_S = 30, \gamma_H = 360$. The processed result in [1] is shown in Figure 6. The effectiveness of the proposed algorithm can see clearly from the comparison of treatment results.

Figure 5. The Result of the Proposed Method

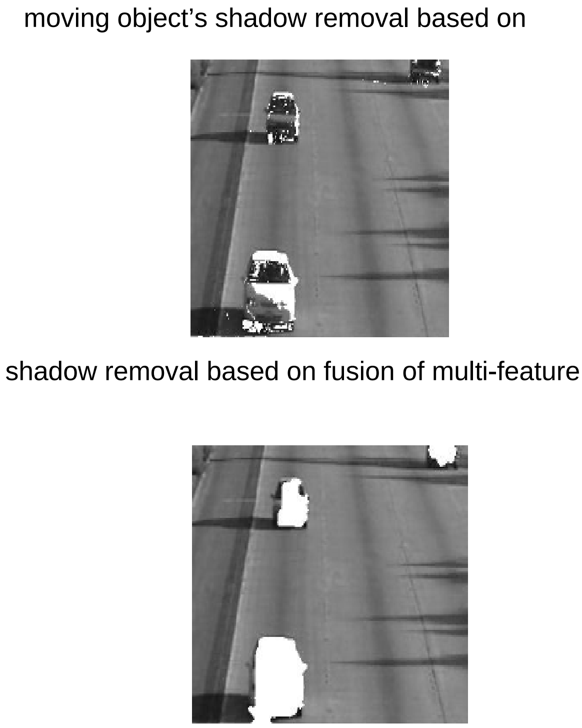

Figure 6. The Result of Reference [1] Method

4.2. The Simulation Results of Laboratory Scenes

Laboratory background reconstruction is shown below. Figure 7 is the average figure of 90 frames, which resolution is 360×240. Reference [2] processes result as shown in Figure 8.

Figure 7. Laboratory Background Image of the Proposed

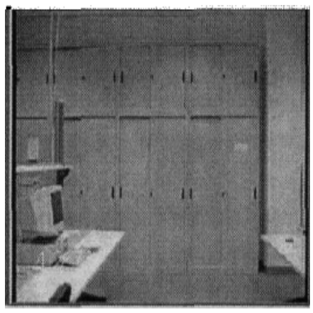

Figure 8. Laboratory Background Image of Reference [2]

Figure 9 is the color space conversion chart. The experimental shadow removal effect as shown in Figure 10. In this section of the video, intensity of illumination is small and the shadow brightness is grate, so $\alpha_V = 0.7, \beta_V = 1, \gamma_S = 30, \gamma_H = 60$.

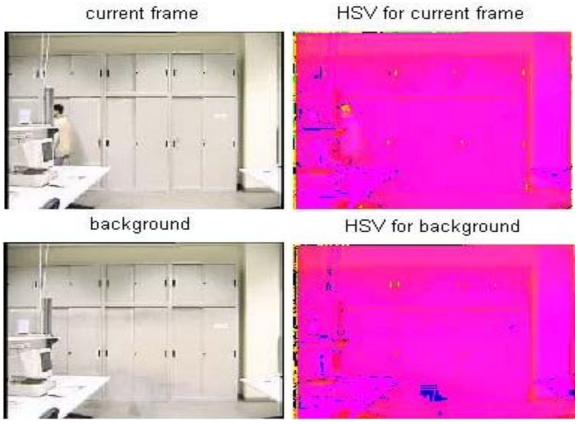

Figure 9. The Conversion Algorithm of Color Space

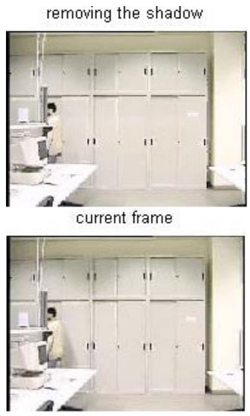

Figure 10. The Result of the Proposed Method

4.3. Campus Scene Experimental Results

Campus background reconstruction is shown below. Figure 11 is the average figure of 90 frames, which resolution is 352×288.

Figure 11. Campus Background Image of the Proposed

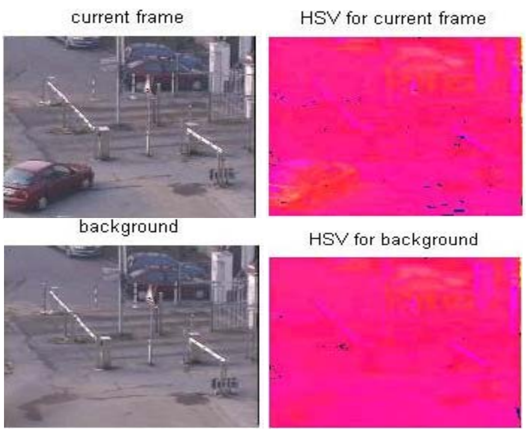

Figure 12. The Conversion Algorithm of Color Space

Figure 13. The Result of the Proposed Method

Figure 12 is the color space conversion chart. The experimental shadow removal effect is as shown in Figure 13. In this section of the video, intensity of illumination is small and the shadow brightness is great, so $\alpha_V = 0.6, \beta_V = 1, \gamma_S = 10, \gamma_H = 100$.

5. Conclusion

This paper proposes one algorithm of removing the shadow based on multi-frame average and HSV color space. Compared to the traditional Gaussian Mixture Model algorithm, this algorithm is simpler and more effective. It is suited to camera fixed embedded device. Moreover, it tries to remove the shadow from different scenes and achieve better results. The next work is to remove the shadow from the slowly moving objective and study the background updating method further to improve its robustness.

References

[1] Huaiyu Liu, Li jing, Liurong Hong. A method based on multi-feature fusion to moving vehicles' shadow removal. *Computer Engineering*. 2011; 37(13); 156-159.
[2] Zhengtie Luo. A method based on gauss mixture model to moving object's shadow removal: [master's thesis. Changsha: School of Computer and Communication HNU. 2010; 5.
[3] Cucchiara R, Grana C, Pieeardi M. Deteeting Moving Objeets, Ghosts and Shadows in video streams. *IEEE Transaetions on Pattern Analysis and Maehine Intelligenee*. 2003; 25(10); 1337-1342.
[4] ITU-TRec.H. 264 /ISO /IEC11496-10, Advanced Video Coding.
[5] Martel-Brisson N, Zaccarina. Learning and removing cast shadows through a multidistribution approach. *IEEE Transactions on Pattern Analysis and Machine Intelligence*. 2007; 29(7); 1133-146.
[6] ANG Jiabin, CHEN Chusong. *Moving cast shadow detection using physics–based features*. IEEE Conference on Computer Vision and Pattern Recognition. Miami. 2009: 2310-2317.
[7] Siala K, Chakchouk M, Chaieb F, Besbes O. *Moving shadow detection with support vector domain description in the color ratios space*. IEEE International Conference on Pattern Recognition. 2004; 4; 384-387.
[8] Yali Deng, Lifang Wu, Yunteng Li. An effective automatic image shadow removal algorithms. *Signal processing.* 2011; 27(11): 1724 -1728.
[9] Liuz, Huangkq, Tantn. Cast shadow removal in a hierarchical manner using MRF. *IEEE Transactions on Circuits and Systems for Video Technology*. 2012; 22(1); 56-66.
[10] Gallegoj, Pardasm. *Enhanced Bayesian foreground segmentation using brightness and color distortion region-based model for shadow removal.* Proceedings of the 2010 International Conference on Image Processing. Washington, DC: IEEE Computer Society. 2010; 3449-3452.
[11] Lee BE, Nguyen TB, Chung ST. *An efficient cast shadow removal for motion segmentation*. Proceedings of the 9th WSEAS International Conference on Signal Processing, Computational Geometry and Artificial Vision. Stevens Point, Wisconsin: World Scientific and Engineering Academy and Society. 2009: 83-87.
[12] Baisheng C, Yunqi L. *Indoor and outdoor people detection and shadow suppression by exploiting HSV color information*. Proceedings of the Fourth International Conference on Computer and In-formation Technology. Wuhan, China. IEEE Computer Society. 2004; 137-142.
[13] Hongjin Zhu, Honghui Fan, Shuqiang Guo. Moving Vehicle Detection and Tracking in Traffic Images based on Horizontal Edges. *TELKOMNIKA Indonesian Journal of Electrical Engineering*. 2013; 11(11): 6674-6683.
[14] Peilong Xu. Study on Moving Objects by Video Monitoring System of Recognition and Tracing Scheme. *TELKOMNIKA Indonesian Journal of Electrical Engineering.* 2013; 11(9): 4847-4854.