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Adaptive Block State Update Method for Separating Background

Youngsuck Ji, Youngjoon Han, and Hernsoo Hahn

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***Abstract*—**In this paper, we proposed the robust mobile object detection method for light effect in the night street image block based updating reference background model using block state analysis. Experiment image is acquired sequence color video from steady camera. When suddenly appeared artificial illumination, reference background model update this information such as street light, sign light. Generally natural illumination is change by temporal, but artificial illumination is suddenly appearance. So in this paper for exactly detect artificial illumination have 2 state process. First process is compare difference between current image and reference background by block based, it can know changed blocks. Second process is difference between current image's edge map and reference background image's edge map, it possible to estimate illumination at any block. This information is possible to exactly detect object, artificial illumination and it was generating reference background more clearly. Block is classified by block-state analysis. Block-state has a 4 state (i.e. transient, stationary, background, artificial illumination). Fig. 1 is show characteristic of block-state respectively [1]. Experimental results show that the presented approach works well in the presence of illumination variance.

***Keywords*—**Block-state, Edge component, Reference backgroundi, Artificial illumination.

I. INTRODUCTION

SURVEILLANCE system has been continuously researched. Surveillance system is used widely to detect vehicles and invaders. Previous researches are focused on the detection of mobile object. Many approaches that focused on the moving object detection usually have used temporal difference image or fuzzy background subtraction through fuzzy learning method [2], pixel-state analysis method [3]. Previous methods use the background model method based on pixel-state analysis can update the reference background more effectively than normal method. But their methods can cause many problems by effects of an illumination and noise.

In normal street images when artificial illuminations such as store or car lamps etc suddenly appear in the evening, previous methods cannot work properly for artificial illumination. And some previous method cannot detect mobile objects and update reference background image exactly.

This paper proposes an improved method that solves the problem of the pixel-state analysis method in night time (night time videos have many noise and diffuse reflection). The proposed method uses the block state analysis to solve the pixel state problems [4]. And each block on the reference background image is updated according to the block state information.

The method can detect mobile object candidate region more efficiently and effectively. Furthermore, when artificial illumination suddenly appears, artificial illumination is exactly extracted through checking the edge component at changed blocks, and update is made according to the proposed method. It is more effectively to detect object on evening time. The system flow of the proposed method is shown in Fig. 1.

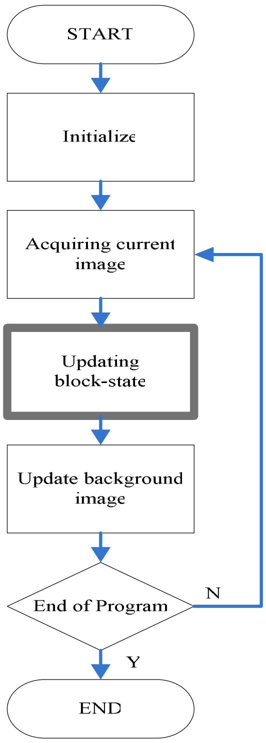


Fig. 1 The system flow of proposed method. When system starts, it does not work until 6th input frame. Because it needs to accumulate statistical information in order to separating background. Updating block-state step is illustrated in Fig. 7

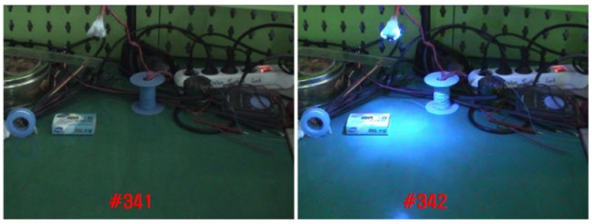
Youngsuck Ji is with the School of Information Technology, Soongsil University, 1-1, Sangdo-5Dong, Dongjak-Gu, Seoul, 156-743, Korea (corresponding author to provide phone: 02-821-2050; fax: 02-826-8937; e-mail: forcepsb@ssu.ac.kr).

Youngjoon Han and Hernsoo Hahn are with the School of Information Technology, Soongsil University (e-mail: young,hahn@ssu.ac.kr).

II. ILLUMINATION REGION CLASSIFICATION

Abruptly artificial illumination protects moving objects from distinguishing moving objects on the input image temporarily. Fig. 2 shows the influence caused by the artificial illumination;

(a) is the image before artificial illumination turned on. Fig. (b) is the image after artificial illumination turned on. Fig. 2(c) is the differential image between the reference background image and the current image. The previous general method using a differential image rarely detect any moving object from the reference background image in that case.



(a) (b)

(c)

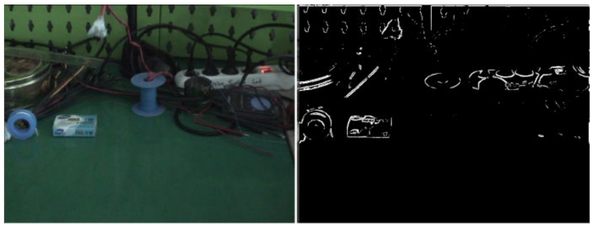
Fig. 2 (a) the image before artificial illumination turned on. (#341 frame) (b) The image after artificial illumination turned on. (#342 frame) (c) the subtraction image of (a) and (b). Since image is affected by suddenly appeared artificial illumination, some parts of foreground objects will not be able to distinguish from reference background image

But the artificial illumination on current input image has very smooth boundary. In other words, boundary of illumination is indistinct because the illumination area preserves their edge components of the reference background. So the artificial illumination region can be found by edge detector. If the edge value on the region is similar to the reference background one while the change rate of the region is larger than any predefined threshold, the region is classified as an illumination one. This property example of artificial illumination is shown in Fig. 3.

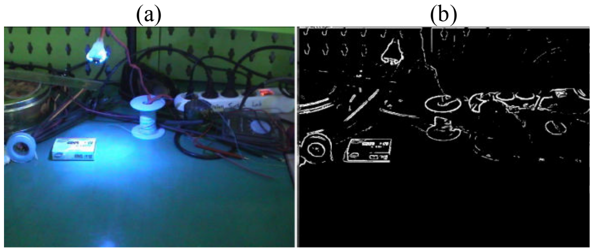
The classification rule of the artificial illumination region is shown as:

$$E = \begin{cases} 1 & |\mathrm{E_{M\_RI}} - \mathrm{E_{M\_CI}}| > \mathrm{thr} \\ 0 & \mathrm{Otherwise} \end{cases} \quad (1)$$

where E_{M_RI}, E_{M_CI} is edge value of reference background and current image at block M, respectively. If E has 0, this block is the appearance of artificial illumination. Constant Thr is the defined threshold value that is obtained by trial and errors. And edge component is detected using sobel edge detector.



(a) (b)



(c) (d)

Fig. 3 Property of artificial illumination. (a) RGB image before artificial illumination turn on. (b) Edge map of (a). (c) RGB image after artificial illumination turn on. (d) Edge map of (c). Edge component of (b) is similar to (d). Lots of wrong detections can be avoided by using this information

III. Block State Intialization of Reference Background

A. Preprocessing Stage

The first input image is set to reference background image. The proposed method set block size to initial size (8*8) according to the image resolution of the experimental image (640*480), and classifies background stat. These blocks are not overlapped, and initial block size is divided according to edge value of each block. If any block M has many edge components, the block should be divided in a smaller size. If many edge components are contained in a region, this means complex structure is contained in the region [5]. So if some object pass through the complex region, it is hard to classify the block of the reference background image as any state. In order to solve these problems, it is necessary to check in details. Block size is determined as follows:

$$\begin{cases} 2\times 2 & \text{If } |E_{M\_RI} - E_{M\_CI}| > E_H \\ 4\times 4 & \text{If } E_L < |E_{M\_RI} - E_{M\_CI}| < E_H \\ 8\times 8 & \text{If } |E_{M\_RI} - E_{M\_CI}| < E_L \end{cases} \quad (2)$$

E_H , E_L constant is the high and low edge value threshold at M block, respectively. It is obtained by trial and errors.

B. Merging Stage

After the state of all blocks is classified, each block is needed to merge some similar blocks according to its block state in order to reduce the classification time. If neighbor block has a same block state except background state, then the blocks are assumed as belonging to the same object. So if some blocks in merged region are changed, it is assumed that the region also changed. Naturally, these changes are under a threshold value.

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C. Initial Block Stage

If the differential image in some blocks of the merged region has changed, the changed edge components exist in the region. Meanwhile, other sub-blocks in the region are supposed to change as well. The region is separated from current image. This process is illustrated in Fig. 4. Since the edge component inside these original blocks has changed, the original blocks, which contain the separated region, should be re-divided into sub-blocks according to the current edge component.

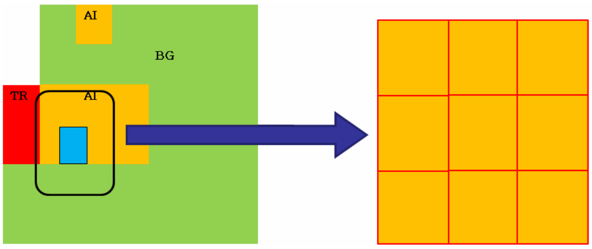
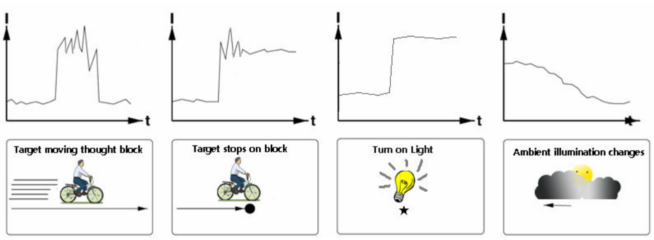


Fig. 4 When changed blocks are found, neighbor sub-blocks are initialized to original blocks, which are re-divided into sub-blocks by current edge component

IV. Reference Background Image Updating by Block-State Analysis

A. Block-state Analysis Method

When there is any abruptly artificial illumination, in general it is classified as foreground. However, unlike foreground objects, artificial illumination cannot hide other regions of the reference background image. So this paper proposes artificial illumination state in addition to existing states of previous methods [3] in order to reduce the effect of the artificial illumination. In this paper, block state is consisted of 4 states: transient, stationary, background and artificial illumination as illustrated in Fig. 5 and 6.



(a) (b) (c) (d)

Fig. 5 Block intensity curve for common event. Moving target passing though a block will cause frequency change, follow by a period of instability. (a): If target passes though a block, its intensity will change to new values first and then returns back to normal. (b): If target stops, the block intensity will first change to new values, and finally stay at a certain value steadily. (c): When artificial illumination suddenly appears, there will be a sudden change of block intensity. (d): Variation in ambient lighting exhibits smooth intensity changes with no large steps

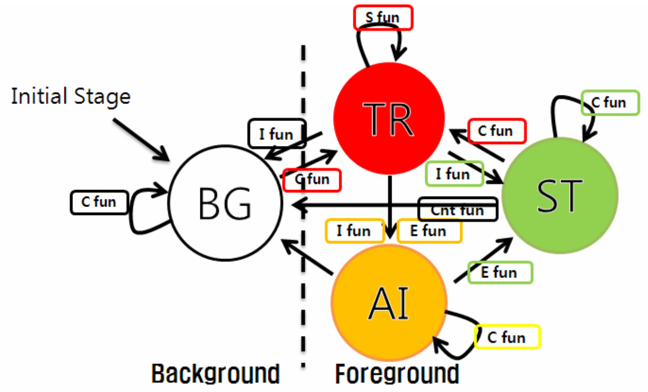


Fig. 6 State transient diagram of the block. Block-states are consist of 4 states. AI, TR, ST and BG denote artificial illumination, transient, stationary and background, respectively

When any M block state has transient state, if transient function value and stability value is lower than threshold value, then it is possible to change other state (BG, ST, AI). Then check intensity value is lower than value. If intensity value is lower than value, then that that state is background state. But, if intensity value is higher than value, then that state is stationary state or artificial illumination state. If Edge component inside block M is similar to edge map of reference background, that block is artificial illumination state. Otherwise, that block state is stationary state where:

Transient state (TR): Transient function value in M block is higher than threshold value. Stationary state (ST): Transient function value in block M is lower than threshold value. Stability value in block M is lower than threshold value by (4). But, intensity value is different to background intensity value in block M. Background state (BG): Transient function value is lower than threshold value. Stability value in block M is lower than threshold value in block M. And intensity value is similar to background intensity value in block M. Artificial illumination state (AI): Transient function value in block M is higher than threshold value. Stability value in block M is higher than threshold value. Edge component inside block M is similar to edge map of reference background.

In surveillance video from a fixed camera, most blocks of input image belong to background, where the block intensity is estimated with the use of a stationary background model. And artificial illumination state is defined according to function (1) and transient function. Transient function is as follows:

$$C = \Big\{ \max\{ \sum_{x,y=\Omega_k} | I_t(x,y) - I_{t-j}(x,y) |, \ \forall j \in [1,5] \} \qquad (3)$$

where I_t (x,y) is the intensity of input image at frame t, and Ω_k is k –th block region.

The stability measure is the stability of the intensity value from time t to the present. Equation is as follows:

$$S = \frac{1}{20} \sum_{x,y \in \Omega_k} \left[5 \sum_{j=0}^{5} I^2_{(t+j)}(x,y) - \Big(\sum_{j=0}^{5} I_{(t+j)}(x,y) \Big)^2 \right] \qquad (4)$$

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Algorithm of the block-state analysis is shown in Fig. 7.

$$I = \begin{cases} |IV_{M\_RI} - IV_{M\_CI}| < THR\_E, & \text{Background} \\ \text{Otherwise} &, \text{Others} \end{cases} \quad (5)$$

Where IV_{M_RI} and IV_{M_CI} is denote mean value of intensity at any M block of reference image and mean value of intensity at any M block of current image.

$$B(t) = \alpha I(t) + (1-\alpha)B(t-1) \quad (6)$$

The constant α determines how fast the block state of the reference background is allowed to update. Artificial illumination state has much more constant α value.

And the background, stationary and artificial illumination state are updated by an Infinite Impulse Response filter (6) to accommodate slow lighting changes and noise in the imagery, as well as to compute statistically significant step-change thresholds. But it is not sure of being maintained to future in stationary state. It may be strongly influenced by any moving object. The number of how long same state has been maintained is counted.

If artificial illumination is appeared on the reference background image, artificial illumination state is updated at once.

A. Experimental Results

The experiments to robustly update the reference background image on varied illumination condition are conducted. Experimental result shows that the proposed approach is more adaptive than previous method. Algorithms are implemented in Microsoft C++ and runs on an Intel 3.0 GHz with 2 GB Ram. Data images are obtained from indoor and outdoor environments. The generated reference background model uses the RGB color information. Under continuously changing illumination condition, the results of the general method and the proposed method are shown in Fig. 9 (a), (b), respectively.

In Fig. 9, the background region in (b) was not exactly detected, but background one in (d) is more exactly detected. The proposed method can detect illumination region using edge component in (d). In case that an object gets near to the fixed camera and illumination is changed in input image, the general method cannot distinguish the object and the illumination effects as shown in Fig. 10(b). But the proposed method can separate the object from illumination effect as shown in Fig. 10(c).

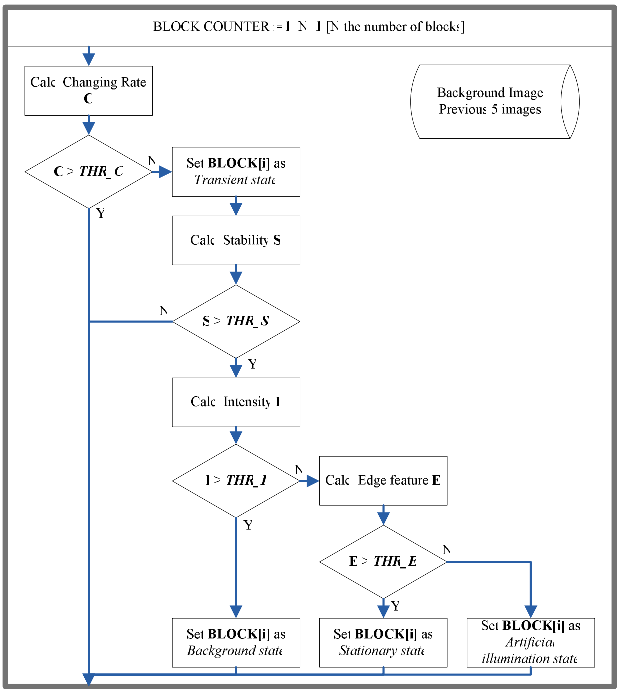
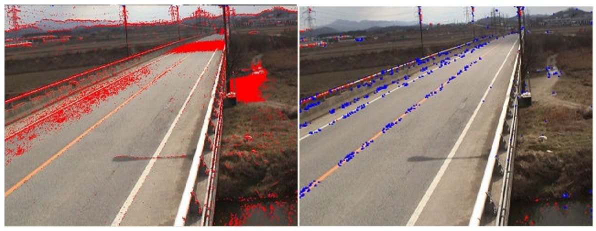
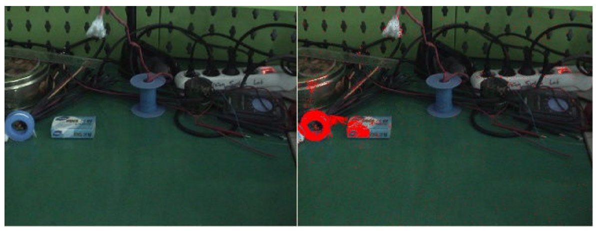


Fig. 7 Algorithm of the block-state analysis. Block-state is analyzed according to (1), (3), (4), (5)

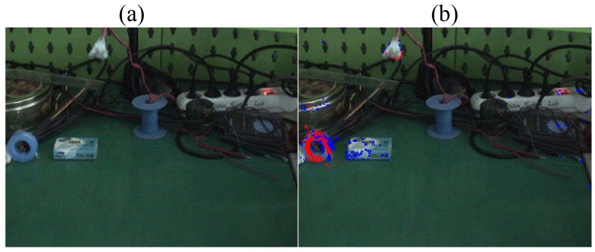


(a) (b)

Fig. 8 When illumination changes very quickly on the road, (a) and (b) show result of reference method and proposed method, respectively. (a) is the result of reference method. (b) shows the result of proposed method. Red color and blue color is transient state and stationary state, respectively



(a) (b)



(c) (d)

Fig. 9 (a) and (c) is input image, when object has been stopped. (b) and (d) shows the result of reference method and proposed method, respectively

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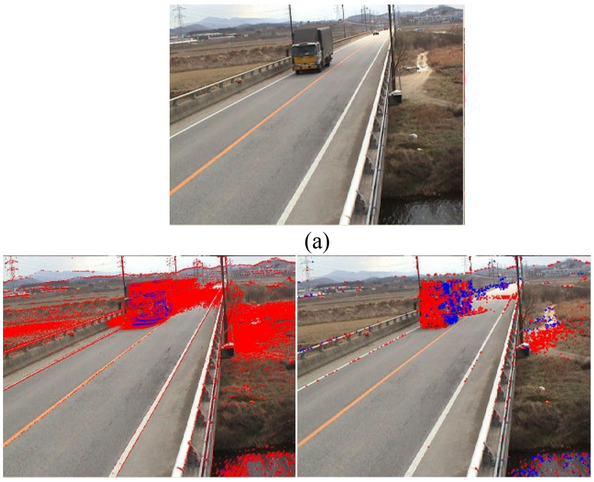

(a)

(b) (c)

Fig. 10 (a) shows the original image when object and illumination are coming in at the same time. Object and illumination are appearing from the top of image to the bottom of image. (b) shows the processing result of reference method . (c) is the processing result of proposed method

V. CONCLUSION

This paper presented the effective method to robustly update the reference background image using block-state analysis on varied illumination condition. The application of the proposed method focuses on distinguishing a moving object from illumination effect. Its result showed more efficient performance than the previous method. Also the block-state analysis is used to control input image noise and diffuse reflection. The proposed method will be applied to robustly detect moving objects on varied illumination condition.

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