A Moving Object Segmentation Method for Low Illumination Night Videos

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Abstract—**Moving object segmentation is one of the important tasks in autonomous system such as security and surveillance system. This paper presents a moving object segmentation method of low illumination video for night surveillance. A unique characteristic of the algorithm is its ability to extract the meaningful information like moving objects with low contrast or low illumination. When the camera system is stationary, background subtraction is a commonly used technique for segmenting out moving objects in a scene. A new approach is specified here to segment the moving object from the poor illuminated area. Also a dilation approach is specified to track the correct pixels. The experimental results on real images show the effectiveness of the approach. Performance analysis is carried out with the help of PSNR and ground-truth measure.**

***Index Terms*— background subtraction, dilation, dynamic matrix, segmentation, surveillance system.**

I. INTRODUCTION

NIGHT video segmentation is one of the most important and difficult components of video security surveillance system[1]. The increasing use of night operations requires that effective night vision systems are available for all platforms. Nighttime images are difficult to understand because they lack background context due to poor illumination.

Surveillance cameras are prevalent in commercial establishments, with camera output being recorded to tapes that are either rewritten periodically or stored in video archives. After a crime occurs – a store is robbed or a car is stolen – investigators can go back after the fact to see what happened, but of course by then it is too late. What is needed is continuous 24-hour monitoring and analysis of video surveillance data to alert security officers to a burglary in progress, or to a suspicious individual loitering in the parking lot, while options are still open for avoiding the crime [2]. The detection of moving object is the first task in many security surveillance systems.

Background subtraction [7] involves calculating a reference image, subtracting each new frame from this image and threshold the result.

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The result is a binary segmentation of the image, which highlights regions of non-stationary objects. The simplest form of the reference image is a time-averaged background image. This method suffers from many problems and requires a training period absent of foreground objects. The motion of background objects after the training period and foreground objects motionless during the training period would be considered as permanent foreground objects. In addition, the approach cannot cope with gradual illumination changes in the scene.

A motion based background estimation using dynamic matrix shows effective background estimation compared to other methods .In this paper dynamic matrix based background estimation is included.

However, the performance of most surveillance cameras are not satisfied at low light or high contrast situations. Low light generates noisy video images, and bright lights (like from car head lights) overexpose the electronics in the camera, such that all detail is lost and the low signal-to-noise image limits the amount of information conveyed to the user with the computer interface [1]. A novel moving object segmentation results an accurate segmentation even in the low illuminated night video.

The morphological operations utilized within most of the surveillance systems to remove noise dramatically undergo the effect of segmentation. Sometimes morphological operators do not reconstruct the required signal. Besides, a fine-tuning of the parameters related to morphological operators is often required .A novel approach is explained to specify the structuring element for low illumination night video segmentation.

This paper is organized as follows. In Section II motion-based background estimation is discussed. Section III introduces a low illumination video segmentation method. Section IV explains a dilation approach. Section V and VI explains extensive results and performance evaluation.

II. MOTION BASED BACKGROUND ESTIMATION

Background maintenance in video sequences is a basic task in many computer vision and video analysis applications [11]. P.Kaw TraKul Pong, R.Bowden [2] implements update algorithms for learning adaptive mixture models of background scene for the real-time tracking of moving objects.

The basic idea of background estimate method comes from an assumption that the pixel value in the moving object's position changes faster than those in the real background [1]. This is a valid assumption in most application fields such as traffic video analysis, people detection and tracking in intelligent surveillance. Under this assumption, a pixel level motion detection method is developed. Which could identifies each pixel's changing character over a period of time by frame to-frame difference method. To improve moving pixel detection a dynamic matrix D (k) is analyzed. The figure shows the flow chart of background estimation.

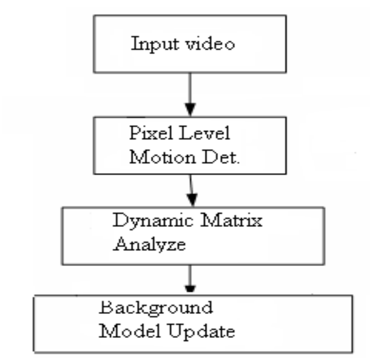

Fig. 1. (a): Flow chart of background estimation

To distinguish the foreground and background accurately a simple frame-to-frame difference method is used, which could detect the fast changes of pixel. However, this method will fail when the inside color of object is uniform. In this situation, pixel values do not vary within the object. To deal with this problem, a dynamic matrix *D* (*k*) is implemented to analyze the changes detection result of the frame-to-frame difference method, where the motion state of each pixel is stored in the matrix. Only those pixels whose values do not change much can be updated into the background.

Let $I(k)$ denotes the input frame at time *k*, and the subscript i, j of $I_{ij}(k)$ represent the pixel position. Equation (1) and (2) show the expression of frame-to frame difference image $F(k)$ and the dynamic matrix $D(k)$ at time *k*.

$$F_{ij}(k) = \begin{cases} 0 & |I_{ij}(k) - I_{ij}(k-\gamma)| > Tf \\ 1 & \text{otherwise} \end{cases} \quad (1)$$

$$D_{ij}(k) = \begin{cases} 1 & F_{ij}(t) = 0, D_{ij}(k-1) \neq 0 \\ 0 & F_{ij}(t) \neq 0 \end{cases} \quad (2)$$

Where γ represent the interval time between the current frame and the old one, Tf is the threshold to make a decision whether the pixel is changing at time k or not, once the $D(k)$ equates to zero, the pixel update method will make a decision that this pixel should be updated into the background B .

Once $D(k)$ equates to zero, the pixel will be updated into the background with a linear model:

$$B_{ij}(k) = \alpha . I_{ij}(k) + (1-\alpha) B_{ij}(k-1) \quad (3)$$

$B_{ij}(k)$ -> is the background image at time ‘k’

α -> Weight of input frame

If $D(k)$ equals to one, the background pixel will be

$$B_{ij}(k) = B_{ij}(k-1) \quad (4)$$

Dynamic matrix analysis of a sample matrix of size 4X4 is as shown below

$$F1 = \begin{bmatrix} 1 & 0 & 1 & 0 \\ 1 & 0 & 1 & 0 \\ 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 \end{bmatrix} \qquad D1 = \begin{bmatrix} 0 & 1 & 0 & 1 \\ 0 & 1 & 0 & 1 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \end{bmatrix}$$

$$F2 = \begin{bmatrix} 1 & 1 & 0 & 1 \\ 1 & 1 & 0 & 1 \\ 1 & 1 & 1 & 1 \\ 1 & 1 & 1 & 1 \end{bmatrix} \qquad D2 = \begin{bmatrix} 0 & 1 & 1 & 1 \\ 0 & 1 & 1 & 1 \\ 0 & 0 & 0 & 0 \\ 0 & 0 & 0 & 0 \end{bmatrix}$$

The estimated background using dynamic matrix is shown below. The input night video contains two foreground objects. The Fig 2.(b) shows that the foreground object is eliminated successfully.

III. MOVING OBJECT SEGMENTATION

Detection of moving objects in video streams is known to be a significant, and difficult, research problem [5, 6]. Aside from the intrinsic usefulness of being able to segment video streams into moving and background components, detecting moving blobs provides a focus of attention for recognition, classification, and activity analysis, making these later processes more efficient since only “moving” pixels need be considered [10,11].

If we monitor the intensity value of a fixed pixel over time in a completely static scene, then the pixel intensity can be reasonably modeled by $N(\mu, \sigma^2)$, the Normal distribution with mean μ and variance σ^2 [15].

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The steps for detecting moving object from low illumination night video is as follows

1. Subtract the estimated background image (B) from the input night video frame (N)

   M=B-N

   Where M, N, B are 3 D arrays where the matrix M (i, j, 1) contains the red intensities of the pixels, M (i, j, 2) the green intensities and M (i,,j 3) the blue intensities .

   .

2. Adding absolute difference of RGB (Red, Green, Blue) intensities in each pixel in the resultant matrix M form a new 2D matrix.

   New (i,j)=| M(i,j,1)|+ | M(i,j,2)|+|M(i,j,3)|

3. Find the minimum value of 'New' matrix

   Val=min (New)

4 Subtract 'Val' from each pixel, so that the maximum Value of 'new ' becomes 255

5 If there is a negative number in the resultant matrix in step 4; make it zero and form a new matrix. Apply a threshold value to get a binary matrix. The new matrix gives the clutters free binary image.

IV. MORPHOLOGICAL OPERATIONS

The two most basic operations in mathematical morphology are dilation and erosion. These operations can be considered as morphological non-linear filters [4]. Both of the involved operators take two inputs: an image to be dilated, and a structuring element (SE).

In this work some portion of the segmented object has less true positive moving pixels. To get more positive (true) signal, a structuring element is specified with size of 3X3. SE is applied if and only if the sliding window matches the following masks. The structuring element and masks are shown below

1	1	1
1	1	1
1	1	1

1	1	1
0	0	0
1	1	1

Fig. 4 (a) Structuring Element (b) masks

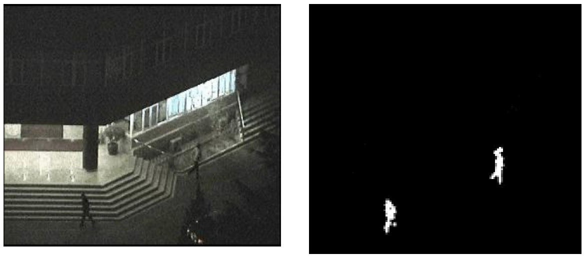
Moving object segmentation result after applying the novel background subtraction approach is shown in Fig. 3 (b). The figure shows an accurate segmentation of two foreground objects from a low illumination video.

V. EXPERIMENT RESULTS

The input of the system is constituted by a 207-frame color video sequence representing a security surveillance system, with 240X320 frame size. A real time night video segmentation system based on the presented algorithm has been developed. The system is implemented on standard PC hardware (Pentium IV).

(a) (b)

Fig. 2 (a) One input frame of the PRbuildings video (b) Estimated background image



(a) (b)

Fig 3.(a) Low illumination night video(PRbuidings) frame (b)Segmentation result after applying the proposed method

VI. PERFORMANCE EVALUATION

To evaluate the quality of the background image with respect to applicability for automatic segmentation algorithms, we can measure the difference between the reconstructed background image and the ground-truth background image. Since the real background image is only available for the *hall-and-monitor* sequence (in the first frames of the sequence), we can use this sequence to obtain the results. Motion based background estimation using dynamic matrix algorithm achieves considerably higher PSNR than the other algorithm, which makes it a better choice for segmentation applications.

Table I: PSNR and SSIM between reconstructed background and real background (*hall- And- monitor* sequence)

	PSNR	SSIM
Average	27.33dB	.9767
Running average	27.69dB	.9796
Dynamic matrix method	32.28dB	.9925

The moving object segmentation performance is evaluated with the help of ground truth measure. Here true positive rate and false negative rates are calculated.

Table II. True positive rate and false negative rate of moving object segmentation (PRbuildings sequence)

Frame No.	True Positive rate	False Negative Rate
140	93.09	0.95
160	90.42	1.84

VII. CONCLUSION

A night video segmentation algorithm is implemented, which could extract moving objects from the low illumination video. Experiment results demonstrate that the system is highly computationally cost effective. The work is more suitable for the security surveillance system.

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