Real Time Moving Object Detection Based on Masking Approach

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Abstract—**Moving object detection has been widely used in intelligent surveillance. This paper proposes a new moving object detection scheme in based on gradient information for real time detection. In the proposed moving object detection scheme, the input and background image are converted into gradient map. Then gradient difference map is calculated and proper masking over the map extracts moving objects. The proposed moving object detection scheme is tested by various video sequences to demonstrate the robustness of moving object detection. Simulation results suggest that the moving object detection scheme embedded with the proposed method are highly robust to illumination change, presence of noise and distracting motions. We observe that the proposed method provides better performance than existing edge based methods in terms of displacement error and false detection because of improved edge localization by new gradient detection and gradient directional masking. Our proposed scheme achieves 25% reduction in displacement error than traditional edge based methods.**

***Index Terms*—Gradient, illumination change, distracting motion.**

I. Introduction

In modern days video surveillance has achieved a great importance in computer vision system. Moving object detection is one of the most important part in video surveillance. This task may seems to be very simple but in real its too difficult. Although many researches have already been done still it is a challenging task. Accurate extraction of moving objects in various environments under different conditions is the main goal of this task which is very hard to gain in practically. In real environment it becomes more hard as the faster extraction of moving object is required in dynamic condition. Moving object detection judges the change in images, captured from the camera and detects whether there is any moving object or not, if there one then extract the object as soon as possible. However due to change in background such as illumination change, presence of noise, distracting motions make detection very difficult.

There are extensive surveys on moving objects detection. Background modelling is very time consuming and complex. Some methods try to use edge segment matching based method. These method works on edge information which may not be stable after some processing steps. Some texture based boundary evaluation methods are also exist but most of them are very time consuming and are not reliable for real time detection.

In this paper we proposed a gradient based method for detecting moving objects with static camera and stationary background. Gradient structure is robust to illumination change. Masking based detection on gradient structural difference provides fast detection with small error rate. Our method can detect moving object effectively under those conditions mentioned above.

II. Related Research

Many existing methods for moving object detection are available. Background subtraction is one of the most popular method which extracts moving object by subtracting the background from the current frame. Moving object detection based on edge is robust against illumination change [1]. Edge represents the structure of an image. Edge extraction keeps the important structural property by discarding less useful information therefore reduce data access rate which accelerates real time moving object detection [2]. Mahbub et al.[3] proposed an edge segment based moving object detection approach using statistical background modelling. This method detects moving objects by matching edge segment of current frame with background modelled edge segments. This method cannot detect moving edge segment that falls upon a background edge segment.. M. Ali Akber Dewan et al. [1] proposed another edge segment based approach. This method takes 3 consecutive frames n-1, n, n+1 as input and computes two difference image between two consecutive frames. Then extract edges from two difference images and attempts to detect moving objects at frame n by applying an edge segment matching algorithm. However this method fails if any moving object at frame n suddenly stops at frame n+1 i.e there is no difference between frame n and n+1. Motion variation of moving objects adversely affects the performance of this method. Kim and Hwang [4] detected moving objects by using edge differencing method with a combination of three edge map. They compute current moving edges and temporary moving edges and by applying logical OR operation between them attempts to detect moving objects. Their method does not update the background. As a result, the method cannot handle background changes and results in higher false alarm.

III. Proposed Method

A. Overview

The proposed method aims at extracting the moving objects in an input image from their background. As depicted

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in Fig. 1, the proposed method consists of three steps: 1) Gradient map and edge map image extraction; 2) Gradient difference image calculation; 3) Masking and thresholding; 4) Background updating. Details of these steps are described in the following sections.

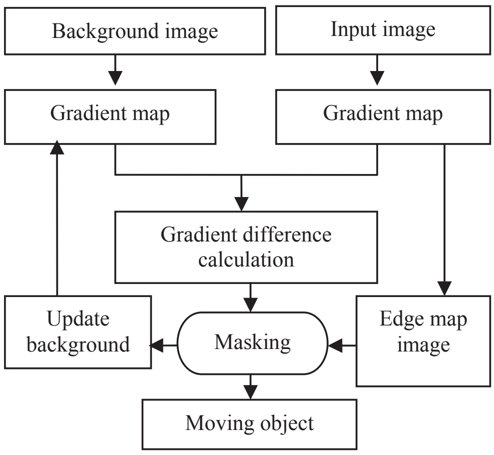


Fig. 1. Overview of the proposed method

B. Gradient and Edge Map Image Extraction

Edges are significant local changes in the image and are important features for analyzing images. Edges typically occur on the boundary between two different regions in an image. Edge detection is frequently the first step in recovering information from images. Due to its importance, edge detection continues to be an active research area. Most of the existing edge based moving object detection methods used traditional Canny edge detection algorithm for extracting edge map. Our method utilizes a new modified Canny edge detection method which provides less displacement error and detect edges directly on RGB images hence there is no grayscale conversion in this method which speed up the real time detection. We introduced a new method for computing gradient magnitude and direction by using the Euclidian distance and vector angle concept. Two 3x3 orthogonal and diagonal mask as shown in fig.2 are used for gradient computation.

For each pixel let $\underline{V1}$ be the vector from the origin of the RGB colour model to that pixel and $\underline{V2}$ be the vector along the main diagonal which represents gray scale line. Then the angular distance of that pixel from the gray scale line through the origin can be determined as:

$$\gamma = \underline{V1} . \underline{V2} \ / \ (|\underline{V1}| * |\underline{V2}|) \qquad (1)$$

0	1	0
1	0	1
0	1	0

(a)

1	0	1
0	0	0
1	0	1

(b)

Fig. 2. (a) Orthogonal mask; (b) Diagonal mask

The 3x3 orthogonal mask is now applied at each pixel to calculate the Euclidian distance between two neighbour pixels in horizontal and vertical direction. Let the distance in horizontal direction is E_H and the distance in vertical direction is E_V. The 3x3 diagonal mask is applied in the same way to calculate Euclidian distance between two neighbours in two diagonal directions. Let the distance along one diagonal is E_{D1} and the distance along another is E_{D2}. Then the total distance between each two neighbours along the four directions can be approximated to the gray scale line of the RGB color model using the angular distance to calculate the gradient value at the centre of the mask as:

$$\delta M_{(x,y)} = (E_H + E_V + E_{D1} + E_{D2}) * \gamma \qquad (2)$$

Where $\delta M_{(x,y)}$ is the gradient map image. The gradient direction is the perpendicular direction of the edge. This direction specifies the direction in which maximum changes occurs. In our method the gradient direction is taken as the direction in which the Euclidian distance between two neighbours is maximum i.e

$$\theta_{(x,y)} = (Horizontal, Vertical, Diagonal1, Diagonal2) | \ MAX(E_H, E_V, E_{D1}, E_{D2}) \qquad (3)$$

The edge map image EM is extracted from the gradient map image by applying non-maxima suppression and thresholding.

C. Gradient Difference Image Calculation

In this paper gradient difference between the input image gradient map and background image gradient map is calculated. Let $G_{B(x,y)}$ be the value of the background gradient map and $G_{C(x,y)}$ be the value of the current input gradient map at position *(x,y)*. Then the gradient difference between the background and the input gradient map at *(x,y)* can be computed as:

$$\Delta G(x,y) = | \ G_{C(x,y)} - G_{B(x,y)} \ | \qquad (4)$$

This gradient difference is significantly very less in no change portion and is very high where change occurs.

D. Masking and Thresholding

Gradient difference map discriminates the structural difference between the input image and background image. This gradient structure provides robustness against illumination change. Most existing edge based methods utilizes proper edge segment matching criteria to differentiate moving edges from the background edges. However when a moving edge falls just upon a background edge then edge segment matching fails by detecting moving edge as background edge. This problem can be easily eliminated by using gradient map which holds not only the position of the edges but also edge information. This information can be used to differentiate overlapped moving edge from the background edge. Moreover from frame to frame background edges may slightly change their position caused by camera shaking, illumination change. Therefore exact edge segment matching fails by detecting background edges as moving edges. Some methods accumulated this problem by taking some reference images of the background and modeled the background by superimpositions of all the reference edge maps and by applying an edge thinning algorithm. In many environments such as busy traffic, supermarket area it is very difficult to collect reference images.

Our method introduced four different masks as shown in fig. 3 for four gradient directions. Gradient direction is perpendicular to the edge direction. Along the gradient direction of a true edge the gradient values from the both sides of the edge to the centre of edges are in structural pattern. The gradient structure for a background edge in both background and input image gradient maps exhibits almost similar pattern. Hence the similarity between two gradient maps at certain positions is calculated. This is accomplished by masking on the gradient difference map. If this similarity is less than a certain threshold value then it is considered as a background edge. For more simplicity number of identical gradient direction scan also is considered.

(a)

1	0	1
1	0	1
1	0	1

(b)

1	1	1
0	0	0
1	1	1

(c)

1	1	0
1	0	1
0	1	1

(d)

0	1	1
1	0	1
1	1	0

Fig. 3. (a) Horizontal maskM_H; (b) Vertical mask M_V; (c) 1st Diagonal mask M_{D1}; (d) 2nd Diagonal mask M_{D2}

For each edge pixel of input image edge map $EM_{(x,y)}$ the respective mask is selected according to gradient direction at that pixel and is applied in the gradient difference map. Let the mask value is $\Delta\delta_{(x,y)}$. The threshold value for the mask at any pixel can be determined as following:

$$T_{(x,y)} = (\delta M_{I(x,y)} + \mu * S) / (S-M) \quad (5)$$

where $\delta M_{I(x,y)}$ is the input gradient map, the size of mask is MxM , S= $M*(M-1)$ and $\mu = \sum \delta M_{I\,(x,y)} / N$ where N is the number of pixels for which $EM_{(x,y)}$ = True. If $\Delta\delta_{(x,y)} < T_{(x,y)}$ then the pixel is considered as a pixel on the background edge otherwise it is on moving edge.

E. Background Updating

Background updating is very important to adapt background scene changes. Many existing edge based detection method have used background modelling. Most of them require some reference background images to model the background. This may not be possible to acquire reference image in a number of environment. Our method only considers the gradient map of the background not the edge map. The location in which no moving object is present, gradient values shows very consistent behaviour in there. Random noise may affect any pixel in the background but masking based detection alleviates the affect. The portion which contains no moving objects is considered as background portion and only those portions are updated. As gradient structure is very consistent, each pixel (x, y) in background poritons is updated as:

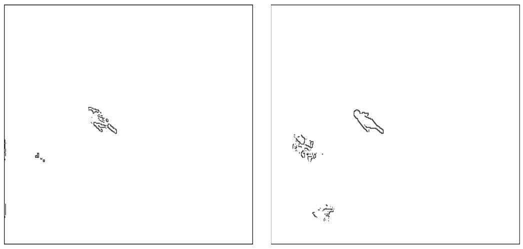
$$\delta M_{B(x,y)} = \beta * \delta M_{B(x,y)} + (1 - \beta) * \delta M_{B(x,y)} \quad (6)$$

where $\delta M_{B(x,y)}$ is background gradient map, β is learning rate and for this method this value is set to 0.5 .

IV. Experimental results

Experiments have been carried out on a number of indoor and outdoor video sequences. We performed these experiments on a desktop computer with processor Pentium IV 3.06 GHz, RAM 256MB. The used programming language is Microsoft Visual C++ 6.0 . The proposed method was compared to conventional edge based methods. We conducted a comparative experiment between our method and the method proposed by [4] and [1]

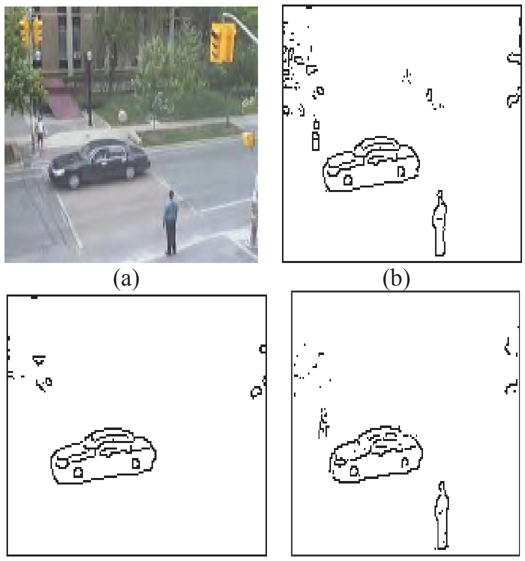
(a) (b)



(c) (d)

Fig. 4. (a) the 339th input frame; (b) Detected moving object by Kim and Hwang method; (c) Detected moving object proposed by Dewan et al. (d) Detected moving object by our proposed method

Fig. 4 shows the experimental result for the indoor video sequence: (a) is the 339th frame of the input sequence; (b) is the detection result given by Kim and Hwang method; (c) is the detection result proposed by Dewan et al. (d) is the detection result given by our method. Fig. 4(b) shows that due to illumination variation Kim and Hwang method [4] detects a lot of scattered edge pixels. The area illuminated by sunlight changes their position with time. As there is no background updating this change causes false edges to be detected as moving edges. Fig. 4(c) shows that some moving objects with small movement are missed in method [1]. Moreover it cannot detect properly the overlapped area between two frames.



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

Fig. 5. (a) the 952th input frame; (b) Detected moving object by Kim and Hwang method; (c) Detected moving object proposed by Dewan et al. (d) Detected moving object by our proposed method

Fig. 5 shows the experimental results for the outdoor video: (a) is the 952th frame image in the video sequence; (b) is the detection result given by Kim and Hwang method; (c) is the detection result proposed by Dewan et al. (d) is the detection result given by our proposed method. Fig. 5(b) shows that the wind blowing tree leaves with small vibration have very strong effect on detection result. Fig. 5(c) shows that the method [1] fails to detect suddenly stopped moving object. Fig. 5(d) shows that the wind blowing leaves with small vibration are not detected by our proposed method.

TABLE I
MEAN PROCESSING TIME (MS) FOR A 640X520 SIZE IMAGE

Processing steps	Mean time (ms)
Gradient map & edge map extraction	30
Gradient difference map calculation	4
Masking & thresholding	26
Background updating	4
Total time required	64

Table 1 shows that the total time required to process an image of size 640x520 is about 64 ms. Therefore our method can process about 15 frames per second which is relatively good for real time detection. By increasing the CPU speed this rate can be improved.

TABLE II
MEAN DISPLACEMENT ERROR

Filter variance σ	PSNR of original image	Canny	Modified Canny	Error reduced
1.0	25.190	1.291	1.042	23%
1.5	25.190	1.273	0.992	28%
2.0	25.190	1.267	1.004	26%
3.0	25.190	1.346	0.999	34%
1.0	21.638	1.299	1.075	23%
2.5	31.354	1.309	0.995	31%

Table 2 shows that the displacement error about 25% is reduced in the modified approach. This error is calculated by the method described in [5]. This reduction locates the moving objects in the input image more accurately.

TABLE III
ERROR RATE (%) COMPARISON WITH EXISTING METHODS

Case	Kim & Hwang	Dewan et al.	Proposed
Indoor images	2.74	5.37	1.78
Outdoor images	5.57	8.93	4.85

Table 3 shows the comparative error rate between our method with the methods [4] and [1]. This error rates are calculated as given in [6]. The computation is performed on almost 25 images by comparing the result with the ground truth images. These ground truth images are calculated at hand.

V. CONCLUSION

In this paper, a new moving object detection method based on gradient information for real time detection has been presented. Simulation results indicate that our proposed moving object detection scheme outperforms existing edge based methods in terms of displacement error, false detection and robustness to illumination change. Our proposed method achieves displacement error 25% reduced in localizing the object in the image and very less detection error rate in contrast with other methods.

REFERENCES

[1] M. Ali Akber Dewan, M. Julius Hossain and Oksam Chae: Reference independent moving object detection: An edge segment based approach. KES 2007/WIRN 2007, part I, LNAI 4692, pp. 501-509, 2007.

[2] M. Yokoyama and T. Poggio: A contour-based moving object detection and tracking. In Visual Surveillance and Performance Evaluation of Tracking and Surveillance, 2005. 2nd Joint IEEE International Workshop on, pages 271-276, Oct, 2005.

[3] Mahbub Murshed, Adin Ramirez, Oksam Chae: Statistical background modeling: an edge segment based moving object detection approach. In Proc. IEEE conf. On Advanced video and signal based surveillance, 2010.

[4] Changick Kim and Jenq-Neng Hwang: Fast and automatic video object segementation and tracking for content-based applications. IEEE transactions on circuits and systems for video technology, vol. 12, No. 2, February 2002.

[5] Ramesh Jain, Rangachar Kasturi, Brian G. Schunck: Machine Vision, McGraw-Hill.,ISBN 0-07032018-7, 1995