An Approach for Real Time Moving Object Extraction based on Edge Region Determination

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ABSTRACT

In today's world ensuring security for important location is a burning issue. Surveillance system is playing an important role in the field of security. Moving object detection has been widely used in video surveillance system. This paper proposes a simple and efficient approach for real time moving object extraction in video sequences where moving object region is extracted from the moving edge map. In this proposed method edge maps are derived from two successive frame difference and background frame difference. Then moving edges are found by comparing these two edge maps and moving edge region is computed. Finally moving object region of current frame is extracted based on the determined edge region.

Keywords

Motion detection, edge region determination, real-time surveillance.

1. INTRODUCTION

Real time moving object detection is core of surveillance applications. One of the main challenges in these applications is to detect moving objects competently and swiftly. Moving object detection judges the change in images, captured by a camera and detects whether any moving object present or not, if there any, extracts the object as soon as possible. Although a number of well known methods are exist, however problem becomes more difficult to solve in presence of noise, illumination changes, complex body motion and in real time environment. Background subtraction is the most common method used in video surveillance, whose basic idea is to compare the current frame with the pixels at the same position on the background model. If the absolute difference is smaller than the threshold, then we consider it background, otherwise foreground. Background modeling, often required in background subtraction, is very time consuming and complex. Some texture based boundary evaluation methods are also exist but their computational costs are relatively high hence they are incompatible for real time purposes.

In this paper, an efficient moving object extraction scheme is proposed which is based on edge region determination. Only background subtraction is not enough to solve illumination change, presence of noise. Besides, background modeling is time consuming and complex. Edge map is derived from gradient structure which is robust against illumination changes. The proposed method is effective and simple to extract moving objects.

The rest of this paper is categorized as follows. Section 2 gives a brief description of related research. Section 3 describes the new approach of our moving object extraction scheme. Section 4 shows the experimental results, analysis and computational cost of our proposed method. Section 5 concludes this paper. The last section 6 includes references.

2. RELATED RESEARCH

Many methods have been proposed for detecting moving objects in video sequences. Background subtraction is a well known approach to extract moving object. The methods [1]-[6] proposed a number of background subtraction techniques. Each pixel in a new frame is compared against a background model and is considered as moving object if it differs significantly from that model. Unfortunately, the derivation of model is complex, time consuming and computationally expensive. Optical flow methods make use of the flow vectors of moving objects over time to detect moving regions in an image. A optical flow based method is proposed in [7], which requires higher computational cost. Moro et al. [8] used visual stereo information for detecting moving objects. This method is also computationally complex. Kim and Hwang method [9], describes an edge based method, which is sensitive to intensity image and requires higher computational cost. Moving object detection based on edge segments is robust against illumination changes. Edges represent the structure of image. Edge extraction keeps the important structural property by discarding less useful information therefore reduces data access rate which accelerates real time detection [10]. Mahbub et al. [11] also proposed an edge based moving object detection approach which utilizes statistical background modeling. Their method detects moving objects by matching every edge segment of recent frame against background edge segments. This method fails to detect the edge segment which falls upon a background edge segment.

3. PROPOSED METHOD

The proposed method is divided into two parts: A) Difference image edge maps calculation; B) Moving object region determination and extraction. Figure (1) shows each step which are given as follows.

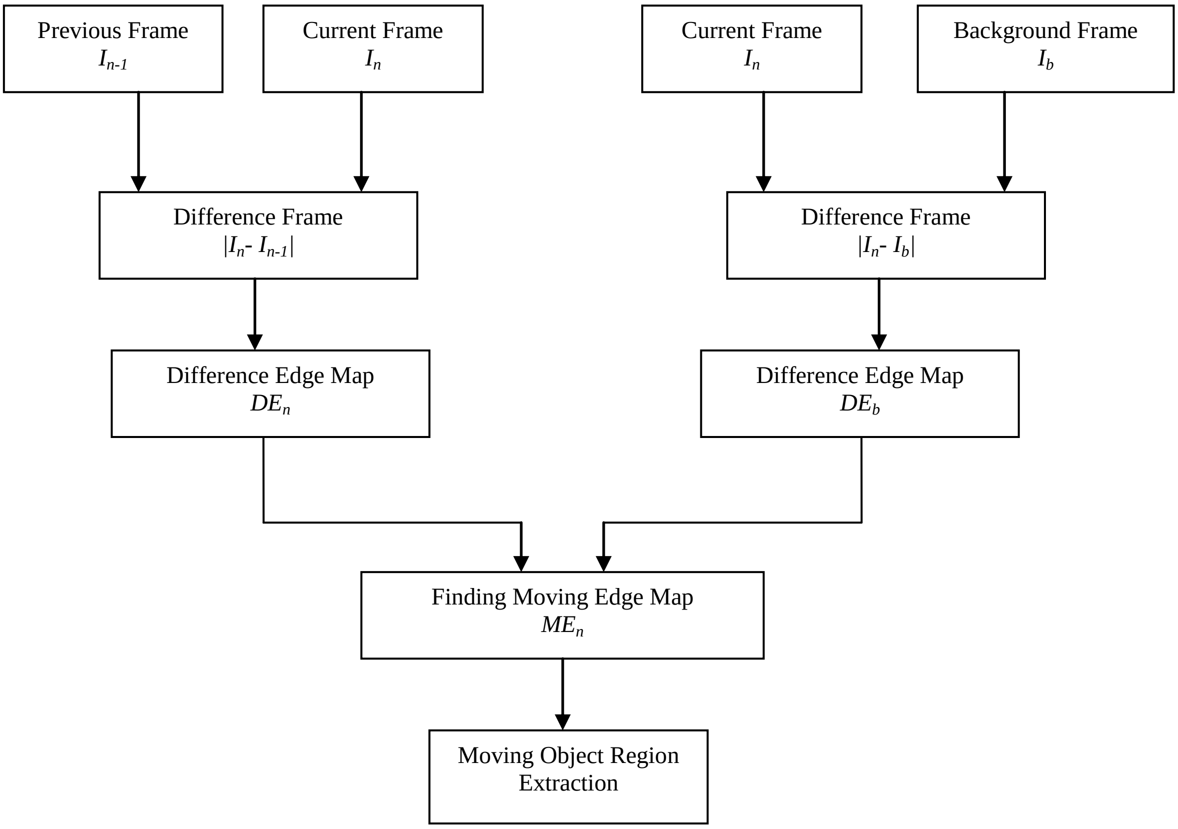

Fig. 1: Overview of the proposed method

A. Difference Image Edge Map Calculation

Fig.1 shows the block diagram of the whole method. Here difference map image of two successive frames is calculated and difference between current frame and background frame. The first frame of video sequences or any initially taken frame can be used as background frame. Difference map image calculation reduces non informative pixels and makes edge derivation faster and specific. Here current frame is defined $\boldsymbol{I_n}$, previous frame $\boldsymbol{I_{n-1}}$ and background frame $\boldsymbol{I_b}$ and have taken gray level image map of these frames for further calculations. Difference map of current frame and previous frame $|\boldsymbol{I_n- I_{n-1}}|$ is determined by taking absolute differences in pixel values of both frame. Background frame and current frame are compared and absolute differences in pixel values are determined to get difference map $|\boldsymbol{I_n- I_b}|$. Threshold is performed on these difference map image to get desired pixel values. After getting difference map edge pixels of these difference maps are calculated.

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 important step in recovering significant information from images. Here we have used Sobel operator for edge detection.

Sobel filtering is an effective method used to extract the boundaries in a given image. The Sobel operator based on convolving the image with a small, separable, and integer valued filter in horizontal and vertical direction and is therefore relatively inexpensive in terms of computations. The operator calculates the gradient of the image intensity at each point, giving the direction of the largest possible increase from light to dark and the rate of change in that direction. $\mathbf{G_x}$ and $\mathbf{G_y}$ values defined in equation (1) and (2) are respectively the values of increase in intensity in the x and y direction. The Sobel edge detector uses a pair of 3x3 convolution masks. The actual Sobel masks are shown below:

-1	0	1
-2	0	2
-1	0	1

G_x

-1	-2	-1
0	0	0
1	2	1

G_y

$$G_x = \begin{pmatrix} -1 & 0 & 1 \\ -2 & 0 & 2 \\ -1 & 0 & 1 \end{pmatrix} * I \qquad (1)$$

$$G_y = \begin{pmatrix} -1 & -2 & -1 \\ 0 & 0 & 0 \\ 1 & 2 & 1 \end{pmatrix} * I \quad (2)$$

Where I is the image source, i.e., difference map image, Gx and Gy are the x and y components of the gradient vector.

Using equations 1 and 2, the magnitude (**G**) and the angle (**Ɵ**) of the edge is calculated that passes thorough the pixel. If **G** is below the threshold, there is no edge passing though the pixel. On the other hand, if it is above threshold, then there is an edge passing through the pixel at an angle **Ɵ**. The threshold value is defined manually. For a given pixel, if its **G** value is greater than the threshold, we make the pixel white; otherwise, we make it black.

$$G = \sqrt{G_x^2 + G_y^2} \quad (3)$$

$$\Theta = atan\left(\frac{G_y}{G_x}\right) \quad (4)$$

Where **G** is the magnitude and **Ɵ** is the angle of an edge.

B. Moving Object Region Determination and Extraction

Edge model is defined $\boldsymbol{DE_n = \{e_1, e_2, e_3, \ldots\ldots, e_k\}}$ as a set of all edge points detected by the sobel operator from the difference of current frame $\boldsymbol{n}$ and previous frame $\boldsymbol{n-1}$. Another edge model $\boldsymbol{DE_b = \{a_1, a_2, a_3, \ldots\ldots, a_k\}}$ as a set of all edge points detected by the sobel operator from the difference of current frame $\boldsymbol{n}$ and background frame $\boldsymbol{b}$. Moving edges can be determined by finding those pixel positions where both difference edge map has edge points, i.e. where $\boldsymbol{e == a}$. Equation (5) represents the moving edge map of current frame $\boldsymbol{n}$ as follows:

$$ME_n = \{\, x \epsilon ME_n : x \epsilon\ (DE_n \cap DE_b) \} \quad (5)$$

Now the region where moving edges exist in the current frame $\boldsymbol{n}$ is needed to be determined. Again, $\boldsymbol{Row_n = \{x_1, x_2, x_3, \ldots., x_k\}}$ as a set of all X-axis values of all moving edge pixels and $\boldsymbol{Col_n = \{y_1, y_2, y_3, \ldots., y_k\}}$ as a set of all Y-axis values of all moving edge pixels of the moving edge map $\boldsymbol{ME_n}$. Then the minimum (x,y) and maximum (x,y) values from all edge points is founded, i.e.

$$Row_{min} = \{x \epsilon Row_n \mid min||x||\} \quad (6)$$

$$Row_{max} = \{x \epsilon Row_n \mid max||x||\} \quad (7)$$

$$Col_{min} = \{y \epsilon Col_n \mid min||y||\} \quad (8)$$

$$Col_{max} = \{y \epsilon Col_n \mid max||y||\} \quad (9)$$

From the value of $\boldsymbol{Row_{min}}$, $\boldsymbol{Col_{min}}$, and $\boldsymbol{Row_{max}}$, $\boldsymbol{Col_{max}}$ defined in equation (6), (7), (8), (9) the moving edge region $\boldsymbol{MEReg_n}$ of current frame $\boldsymbol{n}$ can be determined. Finally the moving object region of current frame $\boldsymbol{n}$ is extracted which is defined in the equation (10).

$$MObjReg_n = I_n(x,y) \begin{cases} \text{where, } Row_{min} \le x \le Row_{max} \\ \text{where, } Col_{min} \le y \le Col_{max} \end{cases} \quad (10)$$

where $\boldsymbol{I_n}$ is the current frame $\boldsymbol{MObjReg_n}$ is the moving object region of current frame, in which region all moving objects are found. It requires much less calculation and computation time than other morphological operations for extraction of single or multiple View Object Plane (VOP). It is much simpler, faster and more accurate to extract single or multiple moving objects within their range in the image frame.

4. PERFORMANCE ANALYSIS

This section gives a brief description of the experiments performed on indoor video sequences captured by a low end camera, comparative analysis and the computational cost of the proposed method.

A. Experimental Results

For this experiment, I used a laptop running Windows 7 Ultimate. The system has the Intel Core i3 processor 2.13 GHz, 2 GB RAM. No other application was running in the background while experiments were performed. The proposed algorithm has been applied to "Hall Monitor," which is a surveillance type of video containing small moving objects and complex background in CIF format.

(a)

(b)

(c)

(d)

(e)

(f)

(g)

Fig. 2: Moving object region extraction of ''Hall Monitor'' CIF format (a)45^{th} input frame; (b)85^{th} frame; (c) 105^{th} frame; (d)198^{th} frame; (e)230^{th} frame; (f)264^{th} frame; (g)294^{th} frame

The experimental results show that the proposed algorithm is quite efficient on surveillance sequences. In order to get accurate edge pixel, less computation time, edge detection is performed on thresholded difference image with background frame. Threshold value for background difference map image $|I_n - I_b|$ is set to 50.

Kim and Hwang method [9] use traditional edge detection technique which is very sensitive to intensity change. Our proposed method can overcome this problem Other edge based method produces multiple responses for a single moving edge. This is because slow motion objects do not provide significant difference in consecutive frames. The proposed method can solve this problem. In this proposed method extraction of moving object region from edge map contains all required information with a low computation cost, where in Kim and Hwang method [9] requires morphological operations for moving object extraction which consumes a good amount of computational cost. For real time moving object detection such as mainly in surveillance system computational cost is a matter of fact. Dewan et al. [12] proposed an another edge segment based approach. Their method utilizes three consecutive frames F_{n-1}, F_n, F_{n+1} and computes two difference images between each two consecutive frames. They extract edges from two difference images and finally detect moving objects within frame F_n by using an edge segment matching algorithm. However if any stationary object present in first consecutive pair, gains motion in third frame or conversely if any moving object present in first consecutive pair, suddenly stops in third frame then their method cannot detect that. The proposed method can overcome this problem.

B. Comparative Analysis

Time for each processing step and total processing time is calculated in this section. Finally the mean processing time is found. Table 1 shows the mean processing time for different steps of proposed method.

Table 1. Mean processing time in milliseconds (ms) for a 352x288 (CIF) size image (proposed method)

Processing steps	Mean time (ms)
Difference map images calculation	8
Edge map generation from difference images	32
Moving edge map calculation and edge region determination	3
Moving object region extraction	5
Total time required	48

Table 1 shows that the total time required to process an image of 352x288 (CIF) size is about 48 ms. Therefore the proposed method can process about 20 frames per second which is relatively good for a real-time surveillance application. By increasing the CPU speed this time can be improved.

Table 2. Mean processing time in milliseconds (ms) for a 352x288 (CIF) size image (Kim and Hwang method)

Processing steps	Mean time (ms)
Difference map images calculation	4
Edge maps calculation	72
Moving edge map calculation	5
Morphological operations	10
Moving object extraction	7
Total time required	98

Table 2 shows the total time required to process an image of 352x288 size for Kim and Hwang [9] is about 98 ms. So, Kim and Hwang method can process about 10 frames per second to extract moving object from surveillance video frames. So, our proposed method can reduce processing time about 51% in contrast with Kim and Hwang [9] method.

Motion detection delay is an important parameter for real-time surveillance application. For an efficient system this delay is to be minimized as much as possible. For this purpose a comparison graph of motion detection delay is shown in figure 3 among proposed method, Dewan-Chae method [12] and Kim-Hwang method [9].

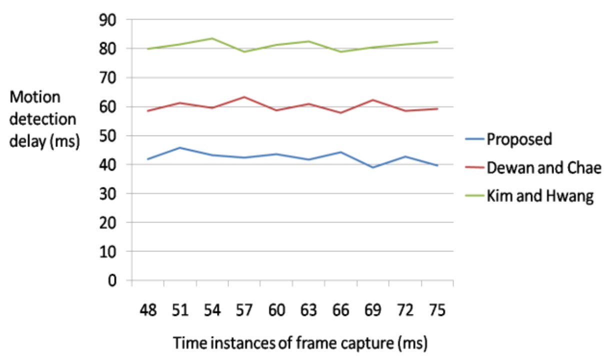

Fig. 3: Comparison of motion detection delay of proposed method with existing methods.

Average motion detection delay for proposed method is about 42 ms which is less than other existing methods. Thus, this method is computationally faster and more applicable for real-time applications.

5. CONCLUSION

This paper presents a cost-effective method for real-time moving object extraction based on edge region determination. Performance analysis results show that proposed method is pretty effective to extract moving object region in surveillance video sequences and reduces motion detection delay than existing methods. Moreover, it needs less computational cost which makes it faster and more applicable for real-time surveillance system. Besides, no morphological operations are performed which makes our method swift, whether most of the edge based methods use these operations to extract moving objects. This method can be applied in military battlefields, restricted areas, traffic monitoring, public and private security purpose. In future, proposed method can be extended for 3D moving object extraction and tracking, recognition and classification of moving objects.

6. REFERENCES

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