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An Improved Algorithm for Moving Object Tracking based on Frame and Edge Differences

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ABSTRACT

Object tracking is gaining interest of researchers in the field of image processing and computer vision. Many methods have been proposed by the researchers in this field. In this paper, an improved algorithm for moving object tracking is proposed based on the frame difference and edge difference methods. Canny edge detector is applied to detect edges of current and previous frames and to get the difference of both edge images. Afterwards, the simple frame difference method is applied on both frames then the result is combined with the resulting image obtained after edge difference. Improved Otsu method is used to threshold the image and morphological filtering is applied to remove noise. Subsequently connectivity analysis is carried out to obtain the moving objects. This algorithm takes advantage of both frame difference and edge difference methods to improve the accuracy in detecting the moving objects. Experiments are performed on various videos which show efficient results in very short time.

1. Introduction

In the modern era of high speed computers, demand and need to automate every system is extensively increasing. In the recent days computer vision field has gained tremendous attention of researchers for video analysis which includes object tracking. With the passage of time this technology is becoming so popular that even individuals are adopting automated solutions in their daily life. Object tracking is simply considered as a process of detecting the object in every frame of a video image sequence and its applications are widely used in the field of traffic management, security zone surveillance, robot vision, automated navigation systems, medical imaging, defense systems and human-machine interface [1-6].

2. Related Work

Video analysis can be divided into three steps; detection of moving object, tracking of detected objects and analysis of behavior of such objects [7]. Many approaches are developed to track moving objects which include background subtraction, segmentation, point detection and supervised learning. For static camera, most commonly used technique is background subtraction. In background subtraction current frame of video stream is subtracted from the background frame. Background frame can be estimated using background model [8] or averaged frame [9], to detect foreground region. But these methods are very complex and take much processing time. The simplest form of background subtraction is the frame difference method in which absolute difference of current frame and the previous frame is calculated to detect the moving object. This method is very adaptive to the changes in background scene conditions.

Moving object tracking profoundly relies on the correct detection of object in frame sequence which leads to further enhancement in the system to correctly identify the target and its behavior. Simple frame difference method sometimes fails to give complete body and exact boundary of object due to taking difference of overlapping parts of the object in consecutive frames. To overcome this shortcoming, Muyun Weng et al. [10] and Zhan Chaohui et al. [11] has proposed some improvements in frame difference method to correctly detect moving objects.

In[10], three frames difference along with background subtraction is employed to detect object. In this method absolute difference between current frame and previous frame, current frame and next frame and current frame and background frame is calculated and then these differences are added together to get a new image. Here the background image is the average image of previous N frames. Then Otsu method is applied to get moving region after thresholding. This method gives good results in detecting object but due to taking difference of three frames it elongates the shape of the object. Further if two objects in a frame are close enough then this technique may merge them to consider as one object. Two more issues with this method are it requires memory to store previous N frames for background modeling and it also takes longer time to process frames.

Canny edge detector is used to detect edges in current

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frame and the previous frame before taking their difference [11], which results in only the edges of moving objects provided that the edges of background of both frames remain the same. Further this image is divided into blocks and decision is made whether a block belongs to the foreground or background region based on the number of non-zero pixels in that block. It utilizes less time as compared to [10] but it lacks in contour integrity of object and also gives false detection by considering a block of noisy pixels as foreground region.

To overcome these weaknesses an improved algorithm is proposed based on frame difference and edge detection. The rest of the paper is organized as follows: Section III describes the proposed technique. Section IV presents some results and gives a comparison with other algorithms. Conclusive remarks are added at the end of this paper.

3. Improved Method for Tracking

3.1. Algorithm flow

The objective of this algorithm is to develop a technique which must process frame in real-time and while detecting object it must maintain counter integrity of the object which can be further used in the identification of the target. This method employs frame difference method in combination with edge difference method to effectively cope with the downsides of each other. Frame difference of current and previous frame gives the body of the objects while edge difference provides only the boundary of the moving objects. Because the edges of background regions remain the same in both current and previous frames so they cancel out each other.Then both frame difference and edge difference are combined together to get the image having complete information of the body of objects and their edges. Complete procedure is described below.

Firstly, absolute difference f_{diff} of current frame f_k and previous frame f_{k-1} is calculated pixel by pixel.

$$f_{diff}^{i,j} = \left|f_k^{i,j} - f_{k-1}^{i,j}\right|. \tag{1}$$

where $f_k^{i,j}$ is the intensity of pixel (i,j) in the current frame k, $f_{k-1}^{i,j}$ is the intensity of pixel (i,j) in the previous frame $k-1$ and $f_{diff}^{i,j}$ is the difference of intensity of pixel (i,j) in the current and previous frames.On the resulting image thresholding is applied to get binary image f_{th} with moving object. Canny edge detector method is applied to get edges of current frame f_{e1} and previous frame f_{e0} and absolute difference of these edge images are taken to get f_e.

$$f_e^{i,j} = \left|f_{e1}^{i,j} - f_{e0}^{i,j}\right| \tag{2}$$

At this stage, logical "OR" operation is applied pixel by pixel on both edge difference, image f_e and image after thresholding f_{th} to get resulting image f_{Or} with complete body of objects.

$$f_{Or}^{i,j} = \left|f_{th}^{i,j} - f_e^{i,j}\right| \tag{3}$$

Finally, two morphological operations, dilation and erosion, are applied to remove noise and connectivity analysis for connected component, labeling is carried out to get moving regions. Complete flow diagram of this method is shown in Fig. 1.

3.2. Segmentation

Otsu method is used to segment the image f_{diff} which was obtained after taking frame difference of current and previous frames. Simple Otsu method sometimes fails when the average color distance between the foreground and background pixels is very small specially when there is no moving object and only some noise is present in the scene. Zhihai Sun et al. [9] has introduced some improvements to solve this problem which are used in this proposed technique with some changes. Suppose the threshold value obtained using traditional Otsu algorithm is T_{0t} and the threshold value obtained using improved method is T_N. Then the mathematical representation of this method is;

$$T_N = \begin{cases} T_{av} & if\ T_{0t} < \varepsilon \cdot T_{av} \\ T_{0t} & otherwise \end{cases}. \tag{4}$$

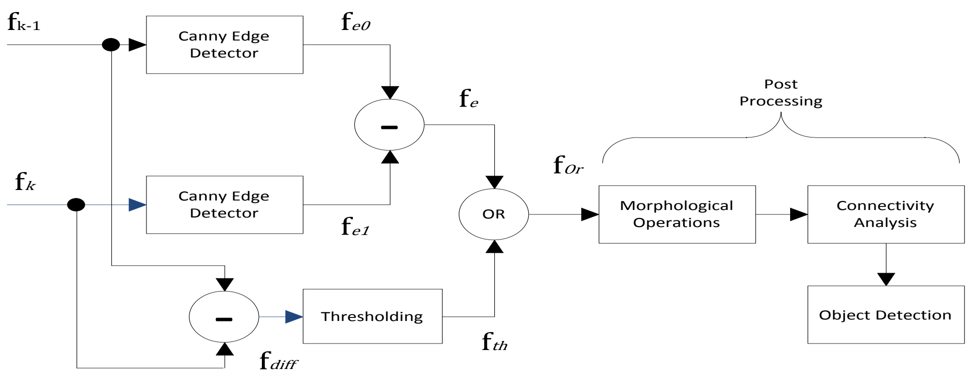


Fig. 1: Flow diagram of proposed algorithm

$$T_{av} = \frac{\sum_{N=1}^{\alpha} T_N}{\alpha} \; with \; \alpha = N - 1. \quad (5)$$

where T_{av} is the average value of previous α threshold values (suitable value is selected initially for corresponding to video) and ε is a weight value, typically its value is $[0.5, 1]$. In present case its value is 0.5.

3.3. Morphological Operations

The image obtained after subtraction of edge images may have broken edges, for improvements dilation operation is performed to repair these breaks within the same objects. The structuring element used in this dilation is 3×3matrix B.

$$B = \begin{bmatrix} 1 & 1 & 1 \\ 1 & 1 & 1 \\ 1 & 1 & 1 \end{bmatrix}. \quad (6)$$

Since the dilation operation increases the size of the objects so to maintain the size of objects, erosion operation is performed with the same structuring element B.This operation removed small noisy object pixels as well, which may be introduced due to illumination changes.

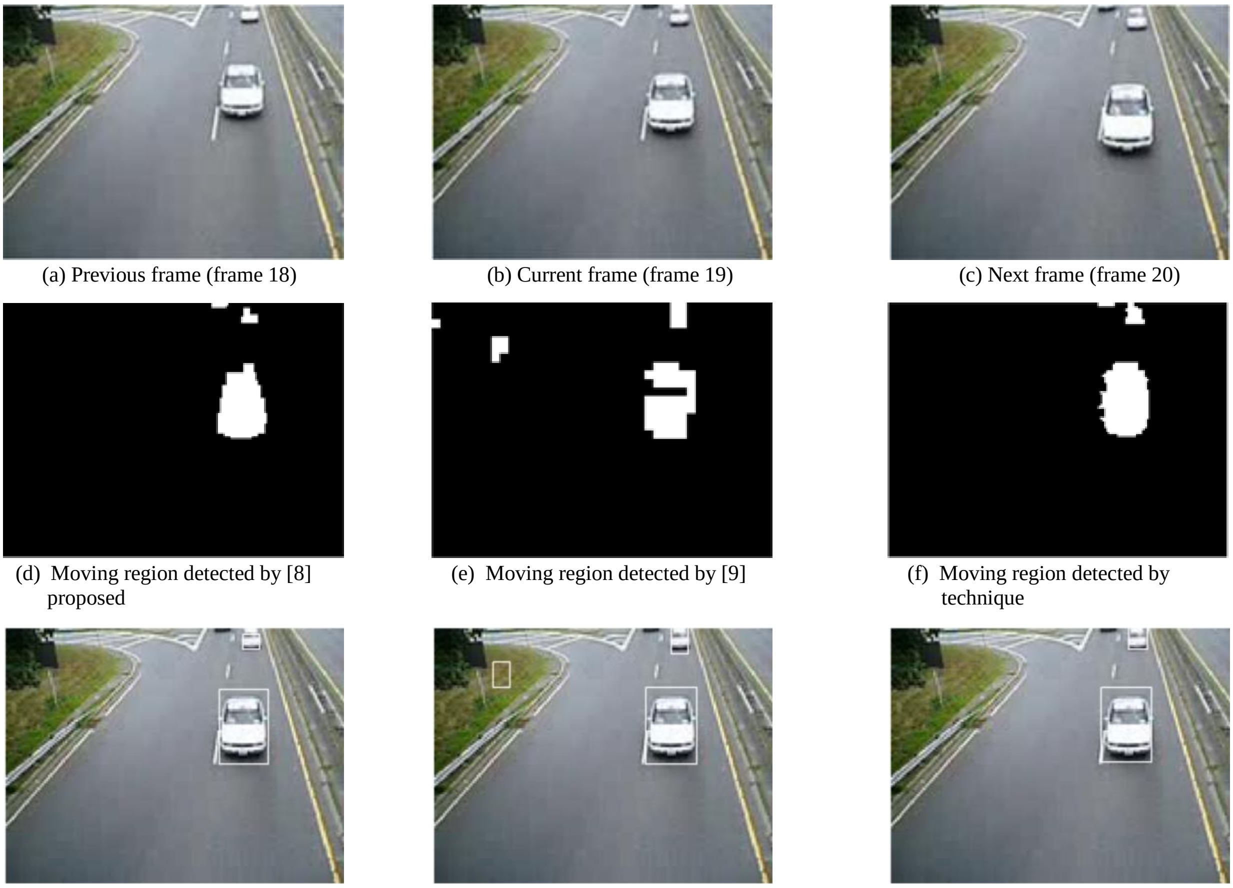
Subsequently connectivity analysis is performed to find the number of connected components and their area. If the area of an object is found smaller than a certain value it is discarded and treated as noise and remaining connected components are considered as moving object regions.

4. Experiments and Analysis

Experiments are carried out on some videos of multiple moving objects to check the effectiveness and performance of the proposed algorithm and the results are compared with the existing techniques.

These experiments are performed on 2.93GHz Core i3 processor, with operating system Windows 7 on MATLAB 7.13. The videos used for testing purposes are 'viptraffic.avi' from MATLAB with frame resolution of 160×120 pixels and second one is a manually recorded video of an underpass with frame resolution of 352×240 pixels in 'avi' format. Experimental results of the proposed method are depicted in Fig. 2 and Fig. 3.

It is obvious from the results shown in Fig. 2 and 3 that the proposed technique has segmented and detected the

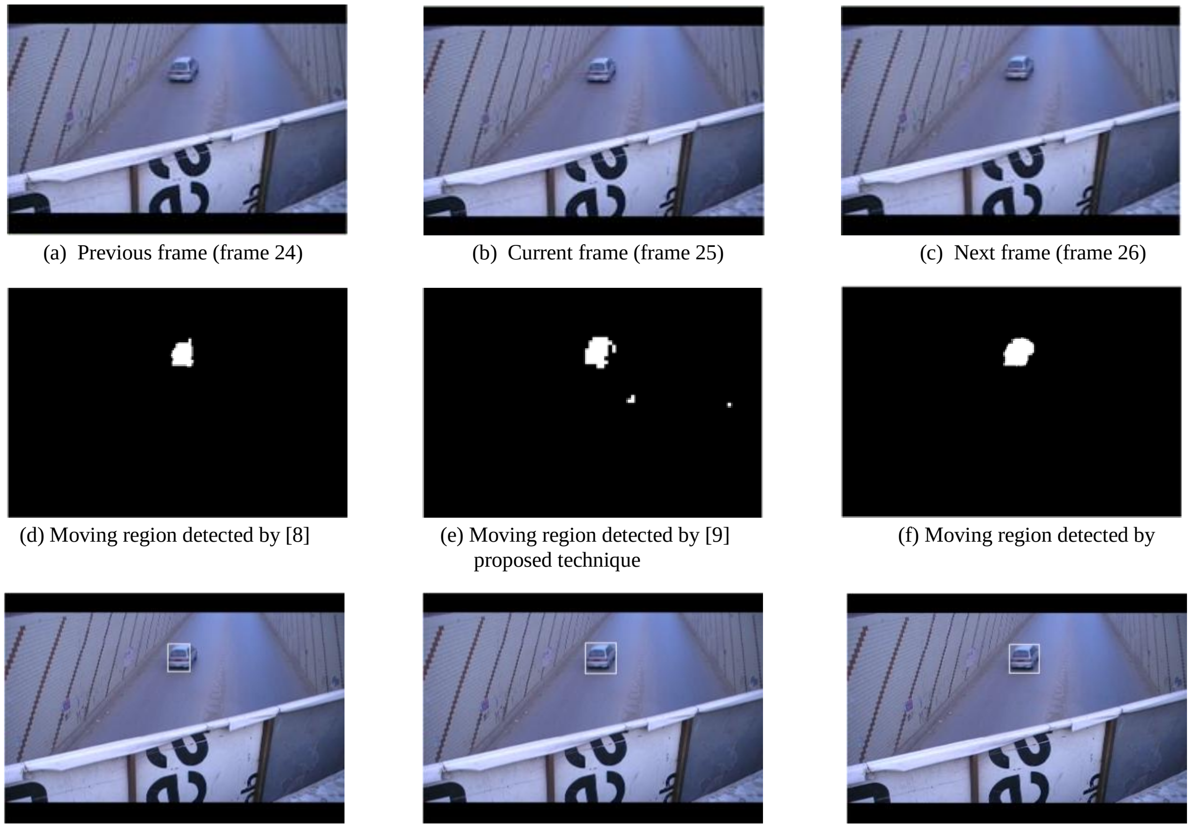


(a) Previous frame (frame 18) (b) Current frame (frame 19) (c) Next frame (frame 20)

(d) Moving region detected by [8] proposed (e) Moving region detected by [9] (f) Moving region detected by technique

(g) Moving object tracking by [8] (h) Moving object tracking by [9] (i) Moving object tracking by proposed technique

Fig. 2: Moving object tracking results for viptraffic.avi video



(a) Previous frame (frame 24)

(b) Current frame (frame 25)

(c) Next frame (frame 26)

(d) Moving region detected by [8]

(e) Moving region detected by [9] proposed technique

(f) Moving region detected by

(g) Moving object tracking by [8]

(h) Moving region detected by [9]

(i) Moving object tracking by proposed technique

Fig. 3: Moving object tracking results for underpass video

moving object more precisely while keeping the contour integrity of the objects than the other two techniques.

Table 1: Processing time comparison.

Methods	'viptraffic.avi' video (resolution 160×120)	
	Time per frame (sec)	*Processing rate (FPS)*
MuyunWeng et al. [8]	0.0862	12
Zhan Chaohui et al. [9]	0.0639	15
Proposed method	0.0533	18

Experiments show that algorithm of [11] sometimes leads to false detection by including the noisy region into foreground region as is the case in Fig. 2(e) and 2(h) also in segmenting out the object from image this algorithm distorts the shape of the objects. Table 1 presents the processing time (in seconds) and processing rate (in frame per seconds) of these techniques for viptraffic.avi video. In order to compare the time consumed by each technique, they are implemented and run on the same system. The proposed technique consumes least time (0.0533 sec/frame) and provides high processing rate than other two techniques.

5. Conclusions

This paper presented an improved algorithm for moving object tracking. Basically, it employs frame difference method as it a faster approach in detecting moving objects and it is highly adaptive to illumination changes in a scene. Edge difference method is used to extract boundaries of objects by combining both frame difference and edge difference methods. Proposed algorithm provides higher tracking accuracy while maintaining contour integrity of the objects which can be utilized for target recognition and identification. Method presented in this paper consumes less time to process frames so it can be utilized in real-time applications.

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