ISSN No. 0976-5697
Volume 2, No. 4, July-August 2011
International Journal of Advanced Research in Computer Science
RESEARCH PAPER
Available Online at www.ijarcs.info

Shadow Elimination to Detect Moving Vehicles on Highway

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Abstract: This paper presents a method to detect moving vehicles accurately without their shadow when shadow is also in motion along with the vehicles. The concept is based on segmentation of moving object from its background. This segmented object contains shadow also along with moving object. Once the moving object is separated accurately from its background next part is to detect object without considering shadow. Here we are deriving spectral property of shadow by considering photometric color invariants normalized RGB. This photometric color invariants of background and object is utilized to separate out shadow from object. Threshold is used here which is applied to the difference of photometric color invariants of background and object for detecting object accurately. The experimental result indicates that the algorithm of detecting shadow is fast and exact, improves the accuracy of the moving vehicle detection.

Keywords: Shadow; elimination; segmentation; moving object

I. INTRODUCTION

Moving object detection in image sequences is fundamental in application areas such as automated visual surveillance, human-computer interaction, content-base video compression, and automatic traffic monitoring [1],[2]. Video Surveillance System using fixed camera to monitor a scene continuously uses digital image processing and Pattern Recognition to deal with the video sequences. When the light source is occluded by a opacity object, shadow is generate. Shadow cast by objects together with the objects form distorted figures [3]. Furthermore, separate objects can be connected through shadows. Shadow is always classified as an object which is normally connected together with the object. Both can confuse object recognition systems. In object recognition, shadows cause difficulty in differentiating and classifying object of interest. The first part of the shadow removal process is segmentation of moving object and most widely used technique for segmentation is comparison of frame with median based generated background. If background frame is steady accurate segmentation of moving object can be obtained however in dynamic case this approach fails to give accurate results. In this paper we have considered this dynamic background case. We have generated background model by median filter approach. Once moving object, vehicle and its shadow is segmented threshold is applied to get mask of moving object i.e. foreground mask [4],[5]. Then photometric color invariant i.e. normalized RGB (rgb) is used for background model and segmented moving object and the difference of this will give shadow free object .Morphological operations are performed and filtering is also done for noise removal to give more accurate result.

The goal of the first part of this paper is to provide a steady background model which is obtained here by median method. As demonstrated in this part under dynamic condition how frame comparison with background obtained by median method can be used to effectively segment out moving object from video when there is no static background.

In the second part of the paper we present a novel framework for shadow removal based on photometric color invariants. Each of the three color components when passing from a lit region to a shadowed one regions where we have a change between lit and shadow, all three components R,G,B suffer from a decrease in their spectral properties values this has been utilized to detect object without shadow accurately.

II. SEGMENTATION OF FOREGROUND

Unlike other change-detection-based approaches [6]–[8], our criterion for motion does not come directly from the frame difference of two consecutive frames. Instead, we construct an up-to-date background information [9] from the video sequence and compare each frame with the background[10]. Any pixel that is significantly different from the background is assumed to be in object region. We have used this comparison of frame and background model to get foreground mask. The background model is shown in Fig.(1).Median based background method is used because when there is no static background we get ghost effect after frame differencing thus to avoid this median based approach is utilised giving stable background. Therefore, we assumed that our input sequence has been properly compensated and the background region is stationary. This helps in getting accurate foreground mask utilised for object detection.

$$BG(x,y,t)=median\{I(x,y,t-i)\} \quad (1)$$

where $i \in \{0,1,\ldots\ldots..n-1\}$
n is number of frames
BG is background at time t
I is current frame

Thus we get static background which is used for differencing.

Figure.1. Background model generated by median approach

Each frame is then subtracted from this background frame and absolute value is considered for further processing. Suitable threshold value is used to determine motion thus segmenting moving vehicle along with its shadow. A foreground mask of this moving object is generated.

$$FG = |BG(x,y) - I(x,y)| \geq Th \quad (2)$$

where FG is foreground mask

Morphological operation using square structuring element is performed on this mask. After this 2D median filtering is done to reduce noise as a result we get mask as shown in Fig.2.

Figure.2. Mask of Moving Object

III. PHOTOMETRIC COLOR INVARIANTSAGE UTILISATION

Spectral property of shadows can be derived by considering photometric color invariants. Photometric color invariants are functions that describe the color configuration of each image point discounting shading, shadows and highlights. We have used photometric color invariant which is the normalized RGB (rgb).It is defined as

$$c_1(x,y) = \arctan \frac{R(x,y)}{\max(G(x,y), B(x,y))} \quad (3a)$$

$$c_2(x,y) = \arctan \frac{G(x,y)}{\max(R(x,y), B(x,y))} \quad (3b)$$

$$c_3(x,y) = \arctan \frac{B(x,y)}{\max(R(x,y), G(x,y))} \quad (3c)$$

This photometric color invariant c_1 c_2 c_3 are calculated for background frame and current frame and absolute difference between these values of background frame and current frame is determined pixel wise applying threshold to obtain shadow free image.

$$C_{background} - C_{current\ frame} < Threshold \quad (4)$$

Fig. 3 below shows difference of one such frame's photometric color invariant with that of background frame and Fig. 4 shows same difference after applying thresholding.

Figure.3.Photometric color invariant difference of background frame and current frame

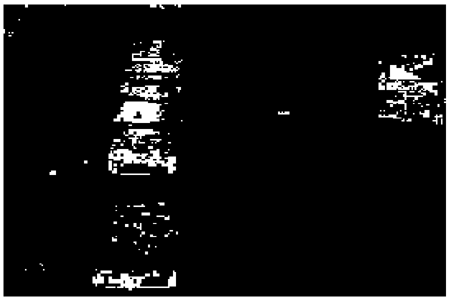

Figure.4. Photometric color invariant difference of background frame and current frame with thresholding.

IV. MOVING VEHICLE DETECTION

Once the mask shown in Fig. 4 is obtained element-wise logical AND operation is performed with Mask of moving object shown in Fig.2.

$$FG\ (c_{background} - c_{current\ frame} < Threshold) \quad (5)$$

This operation gives shadow free object mask as shown in Fig.5.Moving vehicle is enclosed with red color boundary shown in Fig.5.

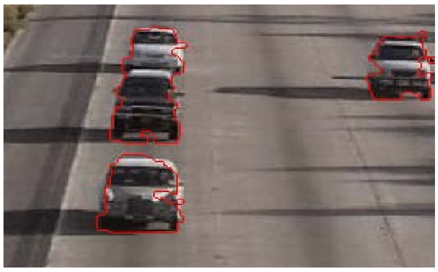

Figure.5. Moving vehicle without shadow enclosed in red boundary

V. CONCLUSION

In this paper, we have proposed robust method for moving vehicle detection ignoring shadow. It is assumed that moving shadows are casted on the dominant background of the scene. They are caused by objects moving between a light source and the background. The shadows spectral properties are compared with spectral property of lit region or object region and after thresholding moving vehicle is accurately detected from its shadow.

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