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Moving Vehicle Detection and Tracking in Traffic Images based on Horizontal Edges

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Abstract

This paper presents a moving vehicle detection and tracking system, which comprising of Horizontal Edges method and Local Auto Correlation. Horizontal Edges characteristic can be strengthened and the influence of weather condition is reduced by using Local Auto Correlation, so the detection rate of extracting and tracking moving vehicles with horizontal edge can be raised. Local Auto Correlation images are generated for vehicle detection and based on Horizontal Edges method. The distance of the gravity center of Horizontal Edges is used to track vehicles in traffic video. We verify the system using a variety of weather (in fog, car shadow existence, morning and evening) traffic video. Experimental results have shown that the high detection rate of moving vehicles be obtained by using the proposed method.

Keywords: *vehicle detection, horizontal edges, local auto correlation, vehicle tracking*

1. Introduction

Vehicle detection is an important and basic technology in intelligent transportation systems, since it allows the enforcement of traffic police with precise information on traffic. Automated video surveillance has emerged as an important research topic in the computer vision community [1, 2]. Applications such as they should be as fast as possible; they should have some means to adapt to illumination changes and they should detect moving vehicles [3]. However, many existing visions-based systems are not able to provide detailed information on individual vehicles but are limited to measuring or quantify the traffic flow only, or to solve specific sub-problems (e.g. queue detection [4, 5], inductive loop emulation, congestion detection on highways [6]), lacking generality.

Real-time vehicle detection and tracking algorithms are required, which can provide higher level recognition capabilities with low-level functionality [7, 8]. Such change detection algorithms mostly rely on either a background subtraction method or a temporal difference method [9]. Background subtraction methods are very suited to detect foreground objects in an image sequence, where the background is known in advance and does not change over time [10, 11]. But sophisticated adaptation methods are required when dealing with changing backgrounds or changing light conditions, and overlapped vehicles in traffic video are difficult to separate for vehicle detection [12, 13].

This paper proposes a vehicle detection and tracking method, which based on Horizontal Edges with Local Auto Correlation (LAC) images. Vehicle area is extracted by using the Horizontal Edges. Stable Horizontal edge is detected for tracking vehicles consecutive frames. And the shape of the vehicle is essentially symmetrical, top feature and bottom feature of vehicle can be strengthened by Local Auto Correlation. Original images are converted to LAC images for vehicle detection based on Horizontal Edges method. Vehicles can be detected with considerably high accuracy investigating trajectories of the horizontal edges in the vehicle area. And overlapped vehicles in traffic video can be tracked separately by using horizontal edges in our system.

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2. Local Auto Correlation Image

Local Auto Correlation is a local approximation of autocorrelation function. In image processing, auto correlation function evaluates the complexity of an image, resulting in a single value for the image. Local Auto Correlation value is calculated on a pixel-by-pixel basis, while the calculation is done over a block of pixels. Local Auto Correlation (LAC) in one dimension is defined by the following equation, where the summation is carried out from +N/2 to –N/2 for even N values. LAC value is computed as follows.

$$\varphi(x,y,\tau_y)=\frac{\frac{1}{N}\sum_{i}^{N} I(x,y+i)\cdot I(x,y+i+\tau_x)}{\frac{1}{N+\tau_y}\sum_{j}^{N+\tau_x} I(x,y+i)^2}. \qquad (1)$$

Here, $\varphi(x,y,\tau_y)$ is LAC value, and N is the size of mask. 1/N in the numerator and $1/(N+\tau_y)$ in the denominator is introduced so that $(\varphi(y,\tau_y))$ tends to be 1 even for small *N* values. LAC has smoothing effect with large value of *N*, the more it enlarges τ_y, the more edge detection effect increases. Given six contiguous pixels, *A*, *B*, *C*, *D*, *E* and *F*, as an example, the LAC value for $N=2, and\ \tau_x=1$ is computed by Eq. (2). In Figure. 1, horizontal direction features can be strengthened after using LAC.

Figure 1. Vehicle Horizontal Features

$$\varphi(B,1)=\frac{\frac{1}{3}(A\cdot D+B\cdot E+C\cdot F)}{\frac{1}{6}(A^2+B^2+C^2+D^2+E^2+F^2)}. \qquad (2)$$

The vehicle has more horizontal features than vertical features in traffic images, the horizontal edge feature can be strengthened after using LAC computing of x direction.

Figure 2. Original Image

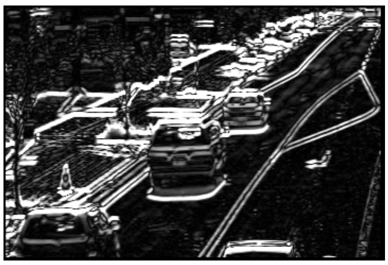


Figure 3. Horizontal Edges after Soble Filter Calculation

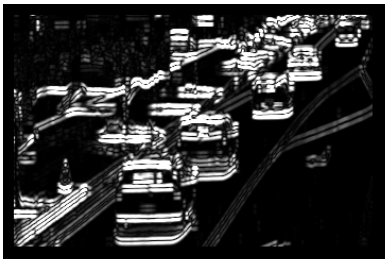


Figure 4. Horizontal Edges after LAC Calculation

Figure 2 shows an example of original image. The result of Soble Filter is shown in Figure 3. We can see some horizontal edges were detected by Soble Filter. We also apply Local Auto Correlation to detect horizontal edges. Figure 4 shows the Local Auto Correlation image. The horizontal edges were enhanced by using Local Auto Correlation. So the horizontal edges which in the Local Auto Correlation image are clearer than Figure 3.

3. Horizontal Edge Detection

In traffic image, When vehicle gradually left the observation point, the proportion of vehicles in the portrait will gradually decrease (see Figure 5)

Figure 5. The Proportion of Vehicles in the Portrait

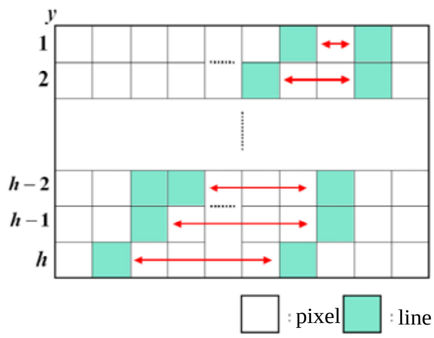


Figure 6. Pixels Calculation between the Two Lines

In order to reduce the impact of the vehicle in the proportion of smaller image of the vehicle detected, the length of the horizontal edge must be normalized and threshold processing. In our system, the rate of change is calculated based on the number of pixels between the white line of the road. Shown in Figure 6 the sum of the pixels between the white lines is the number of pixels on the y-axis coordinate x direction. Equation (3) is used to normalize the edge length of the horizontal edge. Where, $y=h$ is the calculation criteria, WN_y is the number of the pixels between the white lines on the y-axis.

$$R_y = \frac{WN_h}{WN_y}(1 \le y \le h). \qquad (3)$$

In the Figure 7, the vertical horizontal features between two lines were detected, in order to eliminate the excess horizontal edge, based on the histogram processing to achieve a preserved horizontal edge. The histogram was calculated from the pixel value of each horizontal edge to the y-axis projector (see Figure 8), calculate the y-axis coordinate of the horizontal edge of the pixel frequency. Only maxima corresponding to the y coordinate of the horizontal edges were detected in Figure 9. In Figure 10, the detection result was exactly with the original image in the horizontal features of the vehicle.

Figure 7. Horizontal Features between Two Lines

Figure 8. Projection of y-axis

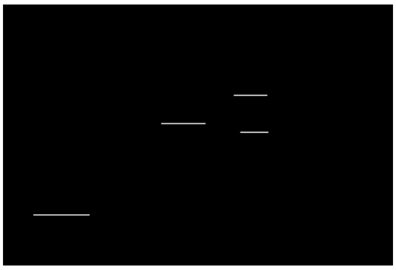


Figure 9. Detection HE of Vehicles

Figure 10. Detection Result

However, compared to the horizontal edge, it is not detected weak in some places of perpendicular edge, or does not necessarily have the feature like horizontal edge. Moreover, the level edge in the level feature is settled within each vehicle's width, and is detected in parallel. So, it judges that horizontal edge is an object better than vertical edge. The vertical edge is not used in our research.

4. Horizontal Edges Tracking in consecutive Frames
4.1. Vehicle Detection

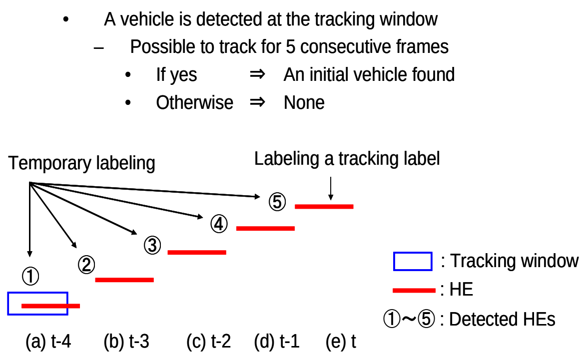


Figure 11. Overview of New Vehicle Detection

A vehicle will be detected as a new vehicle, when it goes through the tracking window, and the HE which in new vehicle can be tracking at least in 5 consecutive frames. Vehicles are moving from near to far, so the HE of the new vehicle is detected in the vicinity of the tracking window. Figure 11 is an overview of the new vehicle detection.

Detect the HE which close to gravity center coordinates of the tracking window firstly. HE detection based on the distance between the gravity center of the tracking window and gravity center of remark HE. Attach provisional label to the HE which has been detected. Since next frame, if the HE can be tracking at least in 5 following consecutive frames. It will be detected as a new vehicle HE, and attach tracking labels to it.

4.2. Vehicle Tracking

Correspondence of the Horizontal Edges tracking in successive (HEs) between two contiguous frames is indispensable. Horizontal Edges *y* coordinates are used for computing the gravity center of the HEs. The frame rate is 30fps, so motion or displacement of moving vehicles in a frame time (33 msec) is small in general, i.e. And the distance of gravity center of HEs is small. However, the positions of the gravity centers fluctuate between frames and frames, so it is necessary to correct their position to make sure that they correspond to their actual motion.

The distance of the gravity center of HEs was computed by using Equation (4). GX_{Ti} and GY_{Ti} are gravity center coordinate of the tracking HE. The minimum of $d_{Ti}(i)$ is computed by Equation (5). Here, T_i is the label number of tracking HE. The overview of HE tracking is shown in Figure 12.

In addition, tracking HE tracks to exit the tracking range. In the current frame, when the tracking HE exceeds the *y* coordinate of the end position tracking, the tracking was exited. Then, it is assumed that the frame over the next frame would not keep track HE.

$$d_{Ti}(i) = \sqrt{(GX_{Ti} - GX_i)^2 + (GY_{Ti} - GY_i)^2} \tag{4}$$

$$T(Ti) = \arg \overset{\min}{i} \; d_{Ti}(i) \tag{5}$$

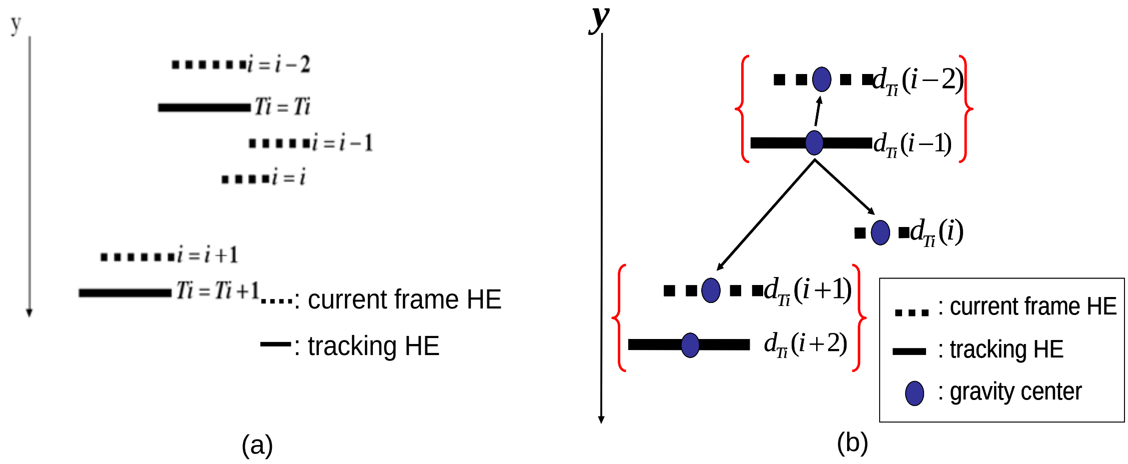


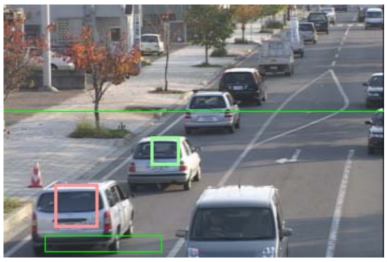
Figure 12. Overview of HE tracking

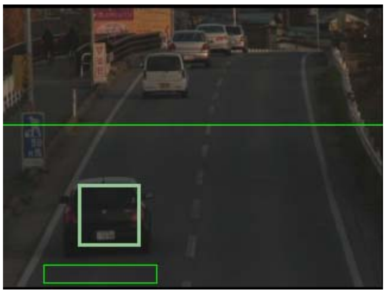
5. Vehicle Detection Result

Vehicle detection results are shown in Figure 13. Bounding box is created based on HE. And the results show that it is possible to detect each individual vehicle even if vehicles are overlapping. Under normal lighting conditions, vehicle color and background color are different, apparently. So moving vehicles can be detected and tracked successfully based on HE method. In poor lighting conditions, such as Figure 15 (c), background color is similar to vehicle color, it is impossible to detect or track moving vehicles using HE method.

Table 1 shows vehicle detection results in 4 kinds of weather conditions. The detection rate achieves 100% in the morning. Although detection rates cannot achieve 100% in the other three kinds of weather conditions, but we have got a higher detection rate based on HEs method. According to experimental results, we can see the shadow of vehicle effect on the detection rates especially at noon, we will work hard on the vehicle shadow detection in our future work.


(a) Experimental results in morning


(b) Experimental results at noon


(c) Experimental results in evening

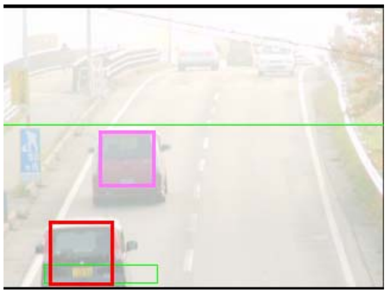

(d). Experimental results in foggy weather

Figure 13. Overview of HE Tracking

Table 1. Classification Results

	Ground truth	Result	Detection rate (%)
Morning (615frames)	9	9	100
Noon (783frames)	10	9	90
Evening (520frames)	12	11	91.6
Fog (820frames)	15	13	86.6
Ave	46	42	91.3

6. Conclusion

Moving vehicle detection and tracking base on HE with LAC image was proposed in this paper. The horizontal features are strengthened and the influence of weather condition is reduced by using LAC images. The effectiveness of our tracking algorithm using the Horizontal Edges for the vehicle was shown in the experiment and told us that vehicle measurement based on traffic video processing is considerably usable in traffic control applications. In our future work, it is necessary to confirm the effectiveness of the proposed method by using more kinds of weather conditions traffic images. And also we will improve detection rate by removing vehicle shadow. After inproving this issue, our algorithm will find many other applications such as monitoring of the speed of vehicle, distance between two vehicles, running direction of individual vehicle, etc.

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