Vehicle Monitoring Based On Taillight Detection

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Abstract. In order to solve the detection of the vehicle at night, a novel vehicle detection method is proposed. According to the lane to be detected, the appropriate detection region and virtual coil should be set. In the detection region, vehicle taillights would be detected and matched, and taillights together with license plate can confirm a taillight-pair represents a vehicle; the accuracy of vehicle detection would be improved. Through matching of taillights in the same lane with that on the former image, the vehicle tracking can be achieved. Experiments show that this method can effectively detect the vehicle position of the vehicle at night, and provides an effective method for monitoring red light runner in the intelligent transportation system.

1 Introduction

The detection of the action of red light runner at traffic intersection is an important part of urban traffic regulation. Due to rich information, large visual range and low cost, the video-based detection systems are widely used. There are several video acquisition modes, such as radar [1], infrared [2, 3] and visible light imaging [4, 5], etc. Owing to the high illumination in the day, the vehicle detection is easy to carry out. However, since the illumination is low at night and the vehicle light intensity rapidly changes, the vehicle detection methods suitable for day can not be applied to that at night. The main difficulties of vehicle detection at night are: 1) No more constant sunshine light at night; 2) Since weak light, the vehicle information available is no much; 3) because of random illumination, vehicle image rapidly change, it's hard to build a stable vehicle model.

Background subtraction is usually used to extract the interesting regions. In such methods, the features of interesting region are extracted, then whether the feature region represents a vehicle would be determined. Literature [6] proposed a vehicle identification method based on color and motion information at night, this method is mainly applied to traffic-flow detection and identification of moving targets in the static background, but it is not applicable to that in dynamic background. Literature [7] proposed a taillight recognition algorithm based on brightness and color, this algorithm can accurately identify taillight, but didn't take into consideration the taillight adhesion, and this method needs the color space conversion and a large amount of calculation. This kind of methods needs extracting and updating background, owing to the low illumination at night, rapid change of vehicle light intensity and noise in video, it is difficult to form a stable background, so the vehicle detection method suitable for the day may not apply to that at night.

2 Vehicle Detection Method

Since only a part of image needs to be processed, it's not necessary to process the whole image. According to the detection range, the detection region is determined. In the detection region, the virtual coil 1 before the stop line is set up; the virtual coil 2 after the stop line is set up, too. As shown in Fig.1.

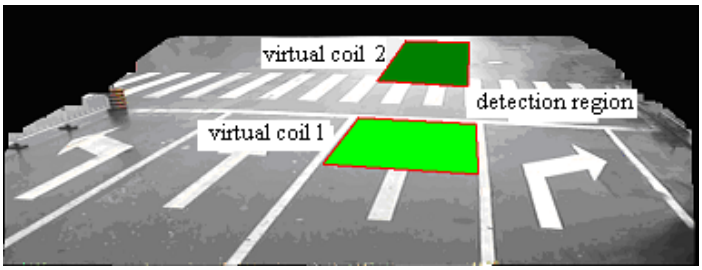


Fig.1. detection region and virtual coil

1）Taillight detection. In the low illumination environment, the vehicle taillight significantly characterizes the vehicle; therefore, the vehicle detection can be substituted with taillight detection. In dark environment, the glowing taillights appear very bright in the image, calculation the pixel grayscale G:

$$G = 0.39r + 0.50g + 0.11b \tag{1}$$

Where G, r, g and b denote the pixel grayscale value, red component value, green component value and blue component value, respectively. Setting an appropriate threshold value, the color components value of the pixel would remain the same whose grayscale is larger than the threshold value; otherwise the color components are set to zero. Thus the bright pixels can be reserved. As the color of the taillights is close to red, defining the red approximation degree (r_m) of the connected bright region:

$$r_m = \frac{\sum_i r_i}{\sum_i (b_i + g_i)} \tag{2}$$

Where 'i' denotes the number of pixels in the connected bright region, the redder the bright region, the larger the value r_m. Selecting a appropriate threshold r_{th}, the region which satisfies $r_m \geqslant r_{th}$ would be regarded as a taillight, otherwise, it would be discarded.

In the virtual coil, the taillights whose distance between each other is less than a certain threshold would be merged into one taillight, and only the taillights which could match each other belong to the same vehicle. By calculating the ratio of the horizontal distance to the lane width, the vehicle could be judged as compact, medium-size and full-size car. The features extracted from the taillight would be treated as that of the vehicle, including the red approximation degree (r_{m1}, r_{m2}) of one pair of taillight and the ratio of horizontal distance to the lane width (R).

2）Matching of taillight pairs. The red approximation degree (r_{m1}, r_{m2}) of each pair of taillight and the ratio of horizontal distance to the lane width (R) construct a feature vector **V=** (r_{m1}, r_{m2}, R), and the vector $\mathbf{V}^p$ and $\mathbf{V}^q$ denote the taillight p and q respectively. The Euclidean distance of the vector $\mathbf{V}^p$ and $\mathbf{V}^q$ could be calculated:

$$d = \sqrt{\left(r_{m1}^p - r_{m1}^q\right)^2 + \left(r_{m2}^p - r_{m2}^q\right)^2 + \left(R^p - R^q\right)^2} \tag{3}$$

The feature vector $\mathbf{V}^p = (r_{m1}^p, r_{m2}^p, R^p)$ denotes taillight features in the current image, $\mathbf{V}^q = (r_{m1}^q, r_{m2}^q, R^q)$ denotes taillight features in information table. If the distance d is smaller than a certain threshold d_{th}, the matching of the two taillights p and q is successful, i.e. the two taillights represent the same vehicle.

3）Vehicle detection combining with license plate detection. To improve the accuracy of vehicle detection, the license plate detection is also required. Setting up a group of virtual coil in the lane, as shown in Figure 2. In the virtual coil, only for the prospect pixels would the frame difference be done. When the difference-value is larger than a certain threshold value, the fuzzy threshold method is used to determine the color attribute of the pixel. The main color of taillight is red, and the main color of license plate is yellow, blue and white. The judging condition is shown in

Table 1:

Table 1. The judging condition

color attribute	Constraint
Red	$\min(r-g, r-b)>Th_{Red}$
Yellow	$\min(r-b, g-b)>Th_{Yellow}$
Blue	$\min(b-r, b-g)>Th_{Blue}$
White	$\min(r, g, b)>Th_{White}$

where Th_{Red}, Th_{Yellow}, Th_{Blue} and Th_{White} denote red, yellow, blue and white threshold value, respectively. From the pixel obtained according to Table 1, the connected region of taillight or license plate could be constructed by region growing.

To screen taillight, the horizontal distance and vertical distance between two taillights would be regarded as a constraint. If there is a license plate in the middle of the taillight-pair, the taillight-pair would be verified a vehicle.

3 Experiments

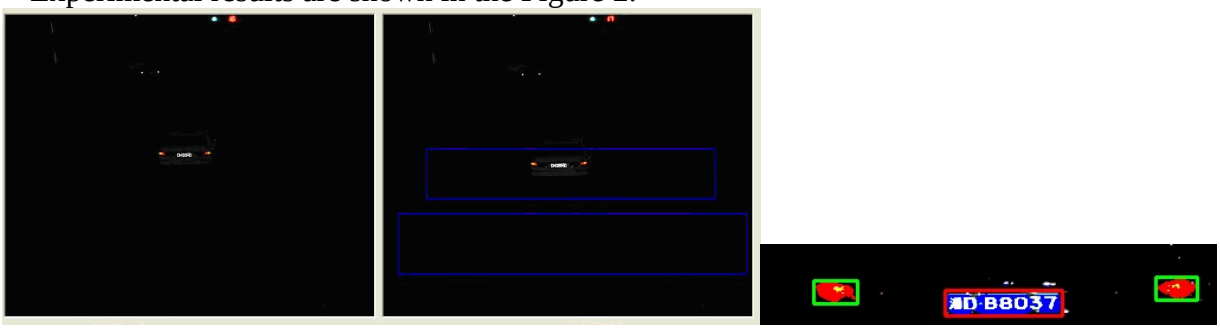
Setting the detection region and two virtual coils in the image, vehicle detection would be carried out in this region. Experimental procedure is as follows:

1) When the traffic light is in red phase, using the detection method above, detect virtual coil 2 and analyze whether a vehicle passed the stop line.

2) If no vehicle is detected in step 1), continue to follow-up video processing.

3) If a vehicle is detected in step 1), using the detection method above, detect virtual coil 1 and analyze whether a vehicle appears on the former image. If there is a vehicle in virtual coil 1, the vehicle should be matched with that in virtual coil 2. If the two vehicles are verified to belong to the same vehicle, it is determined that this vehicle is running a red light, recording the images as evidence before the stop line; If no vehicle occur in virtual coil 1 or the two vehicles don't belong to the same vehicle, the vehicle would not be recorded.

Experimental results are shown in the Figure 2.



(a) Vehicle monitoring (b) Detection of taillight and license plate

Fig.2. The experimental results

4. Conclusion

In order to improve the detection of the action of red light runner at night, a nighttime vehicle detection method based on taillight detection is proposed in the paper. Taillights are the salient characteristic of the vehicle at night, due to the high brightness and notable color, the taillights can be rapidly extracted, and taillight detection can substitute the vehicle detection. To detect taillights, it's necessary to setting the virtual coil in the image. According to the color characteristics and distance of the taillights, the taillights could be paired. Combining with detection of the license plate, the accuracy of the vehicle detection is improved. Experimental results show that this method

can effectively detect the position of the vehicle in the image at night, and provide an effective approach for intelligent transportation systems to monitor the vehicle driving.

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References

[1] Sergi M，Shankwitz C，Donath M. Lidar-based vehicle tracking for a virtual mirror[C]. Proceedings of the Intelligent Vehicles Symposium.USA：IEEE，2003：333-338.
[2] SchreinerK. Night Vision: infrared takes to the road [J]. IEEE Computer Graphics and Applications, 1999, 19(5): 6~10.
[3] TsujiT, HattoriH, WatanabeM, etal.Development of night-vision system [J]. IEEE Transactions on Intelligent Transportation Systems, 2002, 3(3): 203~209.
[4] Fay D A, Waxman A M, Aguilar M, et al. Fusion of multi-sensor imagery for night vision: color visualization, target learning and search [A]. In: Proceedings of the Third International Conference on Information Fusion[C], Paris, 2000:TuD3-3~TuD3-10.
[5] Das S, ZhangY L, KrebsW K. Colornightvision fornavigation and surveillance [A]. In: Proceedings of the Fifth Joint Conference on Information Sciences[C], Atlantic City, New Jersey, USA, 2000:746~749.
[6] Aumann G. Degree elevation and developable Bezier surfaces [J].Computer Aided Geometric Design，2004，21（7）：661-670.
[7] Chu C H，Sequin C H. Developable Bezier patches：properties and design[J].Computer Aided Design，2002，34（7）：511-527.