Hough 변환된 영역의 관심 영역 검색 방법을 이용한 고속도로의 도로 윤곽선 검출

Road Boundary Detection on Highway with Searching Region of Interest on the Hough Transform Domain

Haiping Lin, Jong-Min Bae and Hyongsuk Kim

Abstract - Searching the region of interest on the Hough transform domain is done to determine the real road boundary on the high speed way. The mathematical morphology is employed to obtain the gradient image which is utilized in Hough transform. Many possible candidates of lines could appear on the ordinary road environment and simple selection of the strongest line segments likely to be fault boundary lines. To solve such problem, the search area for the candidates of the road boundary which is called the region of interest is limited on the Hough space. The effectiveness of the proposed algorithm has been shown with experimental results.

Key Words :Road boundary detection, Morphological, Hough transform, region of interest

1. Introduction

To avoid the traffic accidented ensure life to be safe, intelligent vehicles are being improved continually. A lot of researchers show a great interest on road boundary detection. They attempt to obtain the robust and high speed processing of lane boundary extraction technique. Up to present, edge-based detection methods[1], CNN-based DP algorithm methods[2]and lane model based methods [3][4] and some other ways have been developed. Most of the technique shares and combines various principles from these methods.

In this paper, we focus on lane detection of the high speed way and applied a lane boundary detection method which based on Morphological and Hough transform. Firstly, morphological and threshold method are performed to get the edge map. Next, we use Hough transform (HT) which is a global method for finding straight lines in binary image[5] to extract the road boundary candidates from the edge map in the second step. Finally, lane boundaries are detected with searching the region of interest (ROI) on the Hough space.

The remainder of this paper is organized as follows. Section 2 introduces the details of road boundary detection approach. Section 3 presents the lane boundary detection with analyzing ROI on Hough transform domain. Section 4 presents the experiment results of our method and Section 5 is the conclusion.

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2. The road boundary detection

Being well known, the high speed way images have several obvious characters: clear lane marks, a little shadow, illumination changes slowly and traffic is not heavy. Such as this uncomplicated road situation, we combine the morphological-based approach with HT[6] to detect the lane boundary.

2.1 Morphological-based edge detection

As we known, edge map shows us much useful information about the road boundary. For the grayscale image $f(x,y)$, traditional edge detection methods, such as Robetrs, Sobel, Prewitt and Laplacian-Gauss[6], are all based on the difference of gray levels. Mentioned methods are suitable for detecting all of edge pixels accurately, whereas, the more edge pixels, the worse influence with boundary detection. For highway images, morphological -based threshold edge extraction method will create an effective edge map with little noise. Fig.1 shows one case of our experiments.

In this stage, Dilation, one of the fundamental morphological operations, is employed to process the gray-scale road image[6]. The gray-scale dilation of image $f(x,y)$, by element b, denoted $f \oplus b$, is defined as:

$$(f \oplus b)(x,y) = \max\{f(x-x',y-y') + b(x',y') | (x',y') \in D_b\} \quad (1)$$

Where x and y are spatial coordinates of road image, D_b is the domain of b. Fig.2(a) shows the results of dilation. And then, we subtract original gray-scale image from its dilated version to produce a morphological

gradient image which was presented in Fig.2(b).

After processing the gradient image with an optimal threshold value, Fig.2(c) shows the finally edge map. Comparing with the traditional edge detection ways, the advantage of this method is clear.

Fig.1 An example of original gray-scale images

(a)

(b)

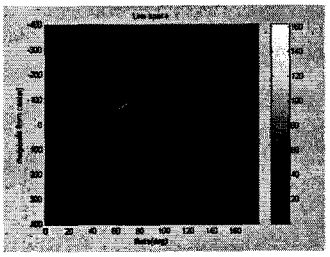
(c)

Fig.2 Dilation-based edge detection: (a) dilated image (b) morphological gradient image (c) edge map

2.2 Lane boundary candidate detection with HT

According to the linear characteristic of road boundaries, Hough transform is applied to find road boundary candidates form the edge image.

HT is a robust global method for straight line detection in binary image. Being processed by HT, each edge point (ρ,θ) in Hough space corresponds to a line at orientation (angle) and distance from theorigin point. The $N(\rho,\theta)$is the number of the edge points according to the linear equation $\rho = x\cos\theta + y\sin\theta$. Hough space accumulator voting was represented in Fig.3(a). The local maxima of $N(\rho,\theta)$ which means high brightness can be used to detect straight line segments passing through edge peaks. With some threshold values (T), you can select lines as many as you want. Fig.3(b) shows the results of the straight line candidates using HT.



(a)

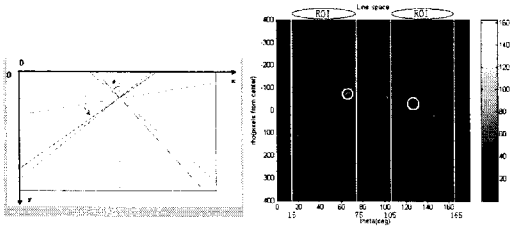
(b)

Fig.3 Line detection with HT: (a) Hough space accumulator voting (b) line candidates detection results with T=.40

3 Redundant lines elimination with searching the ROI on the HT space

After dilation-based edge pixels extraction and lane candidate detection with HT, the important thing to how to eliminate redundant lines. The goal of our experiment is to detect both of the internal road boundaries.

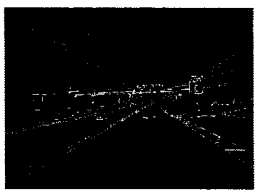
Hough space provides the orientation $(\theta)$of the lane candidates. Therefore, in the angle matrix, searching the local maxima within some restricted range on the Hough space is helpful. To be pixels on the right lane boundaries the edge orientation of the pixels should be in range of $15^\circ < \theta_r < 165^\circ$, similarly, the range of left lane should be in range of $105^\circ < \theta_l < 165^\circ$. With these reasonable assumptions of the highway boundaries, we can only analyze the region of interest (ROI)on the Hough space. The geometric interpretation of θ describes in Fig.4 (a) and Fig.4(b) shows the ROI.



(a) (b)

Fig.4 Redundant lines elimination: (a) the geometric interpretation of the orientation(θ). (b)ROI

(a)



(b)

Fig.5 The results of traditional HT (left) and the result of our method (right)

Otherwise, according to Fig.2(c), we can easily find no foreground pixels in the road domain between left and right boundary. The magnitude of pixels on road boundaries is large, which means the angle of lane boundary existing in the angel matrix of peak point neighborhood. In ROI, we can extract suitable quantitative lane candidates with an optimal T (T=.40 was used in our experiment). Two point circles have highest value and correspond to two main sets of lines. Based on Fig4(a), the smallest and the biggest angel are our expectation.

Compared with traditional HT lane detection technique, searching ROI on Hough space will save cost time and advance the validity of lane detection. For some special case, the advantage of the posed algorithm is obvious. Fig.5 shows the difference.

4. Experiment results

We tested the proposed method on several road video sequences. All sequences were with 480*600 pixels. Fig.6 shows some experiment results of proposed method and Fig.7 shows the failed result by traditional HT lane detection.

In real word, the driver could be alerted on time to avoid an accident if the lane angel is out of the range of θ_l and θ_r.

Fig. 6 Results of Lane detection

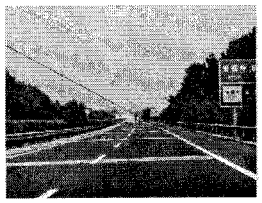


Fig. 7 the failed result of traditional HT

5. Conclusion

We proposed the method, which is Morphological and HT-based road boundary detection method in high speed way. Although there are many limitations in our way, I believe, its fast processing and robust detection of the high speed road boundary will be engraved on your memory. In future work, we plan to combine some other algorithms with the information in this stage for curving road boundary detection.

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