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A Novel Algorithm Research on Lane Recognition Based on Hough Space

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Abstract. A novel method for lane marking recognition that includes two sections was introduced. The image pre-processing section got the gray image by using methods of gradation and histogram equalization. Binarization was used to get the region of interest (ROI). The boundary of ROI was obtained through morphology operation and edge detection. The left and right lanes were detected in the lane detection section through Hough transform basing on the special positions of lanes. Experiment results indicate that this novel algorithm features fast, precise and reliable.

Keywords: Lane detection, Hough transform, Image processing.

Introduction

With the development of Intelligent Transport System (ITS), the researches of Drive Assistance Systems (DAS) have become the hot topics [1]. The DAS should have the functions of road and obstacle detection in order to give warns to stop from crashing or deviating [2]. And the technology of lane recognition is the basis of these functions [3]. This technology can be achieved by using vision sensor and radar sensor [4]. The technology basing on vision sensor is easily influenced by the external environment; while the technology basing on radar sensor is high in cost [5]. So this kind of technology is mainly achieved by using the algorithms in image processing field. The revised method can solve the problem of low contrast caused by light changes and the problem of error identification caused by the roughness of lane edge. At the same time, this method has higher processing rate and higher accuracy.

Image Pretreatment

The original image collected by CCD camera contains lots of non-lane information such as the human beings, vehicles, buildings, trees and the sky. Fig.1 shows the original image.

Fig.1 Original image

Gradation and Histogram Equalization. The RGB image contains lots of information; though the gray image contains less information, but it can show the information of three dimensions.

$$f(i,j)=a*R(i,j)+b*G(i,j)+c*B(i,j). \quad (1)$$

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Multiple experimental data indicate that it is better when $a=0.3$, $b=0.59$ and $c=0.11$. In order to improve the processing speed, the original image needs gradation.

Different illuminations would contribute to the problem of concentrated phenomenon of grey level which would affect the precision of the subsequent processing. So in order to improve the contrast of the image, histogram equalization is needed. Histogram equalization is a method in image processing of contrast adjustment using the image's histogram.

Image Binarization. In order to achieve the segmentation between the suspected lane area and background area, the image processed by histogram equalization needs binarization transformation. Eq.2 shows the image binarization equation.

$$binaryzation(i,j)=\begin{cases}0 & f(i,j)<T\\ 255 & f(i,j)\ge T\end{cases}. \quad (2)$$

As is shown in Eq.2, T is the segmentation threshold. OTSU method could be used to calculate the threshold. And this method can satisfy the required precision and has higher processing speed at the same time. Binarization process can reserve the lane line effectively because the color of lane is always the light color.

Edge Detection and Morphologic Processing. The edge detection is the name for a set of mathematical methods which aim at identifying points in a digital image at which the image brightness changes sharply or, more formally, has discontinuities. In order to extract the lane edge which can reduce the calculations of subsequent processing, the suspected lane area needs edge detection operation. An edge detection operator named Sobel is used to detect edge points and enhance the edges. Eq.3 shows the convolution kernel of $45°$ and $135°$ templates.

$$\begin{bmatrix}-2 & -1 & 0\\ -1 & 0 & 1\\ 0 & 1 & 2\end{bmatrix}\ \begin{bmatrix}0 & 1 & 2\\ -1 & 0 & 1\\ -2 & -1 & 0\end{bmatrix}. \quad (3)$$

Sometimes the image contains buildings and railings whose color is light color and they would be considered as suspected lane area by image binarization operation. For the buildings, lots of edges would be detected because the buildings contain many separated windows. The railing area would also have lots of edges because of the same reason. The mentioned redundant information would increase the computations and thus reduce the processing speed. Morphologic processing is needed to erase the small interval areas and thus reduce the redundant edges. Morphologic processing is a kind of method to remove the irrelevant structure on the premise of keeping the basic shape characteristics.

Fig.2 shows the image processed by image pretreatment.

Fig.2 Image processed by image pretreatment

Image Pretreatment

Left and right side lane can be detected respectively through dividing the image into two parts.

Hough Transform. The Hough transform is a kind of technique is to find imperfect instances of objects within a certain class of shapes by a voting procedure. This voting procedure is carried out in a parameter space $\theta-\rho$, from which object candidates are obtained as local maxima in a

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so-called accumulator space that is explicitly constructed by the algorithm for computing the Hough transform. Eq.4 shows the relation between the image space $x-y$ and parameter space $\theta-\rho$.

$$\rho = x\cos\theta + y\sin\theta . \quad (4)$$

Identification of the Left Lane. The lane can be extracted from the edges of suspected lane area, taking the advantages of position of the lane. Concrete steps are shown as bellow:

Step 1: Extract the left part from the edge image.

Step 2: Operate the Hough transform and extract the point in the straight line whose equivalent ρ is maximum.

Step 3: Several cuttings are employed on the bottom part of the left edge image which can make each tailored image has the same number of columns but has different number of rows. Repeat *Step 2* and thus get several points in the straight line.

Step 4: After eliminating the error points, the method of least squares is applied to fit a straight line. And this straight line is just the traffic lane.

During this process, the straight line whose equivalent ρ is maximum value is not the longest line. This is because the lane edges are out-of-flatness. The point in the straight line whose equivalent ρ is maximum value is generally the bottom point near or on the inside part of left lane. Inverted images of streetlights on the both sides would cut off the lanes and thus the lanes would have sunken edges. Besides, other light color objects that are sitting inside the lanes would cause error detection. Tailoring the edge image several times can solve these mentioned problems at the same time, thereby improving the accuracy.

Fig.3 shows the left lane recognition result. The left part of the result image is non-recognition image and the right part of the result image is the recognition image.

Fig.3 Result of the left lane detection

Fig.4 Result of the right lane detection

Identification of the Right Lane. The method in the right lane detection is similar with the method in the left lane detection. Concrete steps are shown as bellow:

Step 1: Inverted reflection operation is applied in order to make the right lane become the left lane.

Step 2: Carry out the steps in the left lane identification.

Step 3: Inverted reflection operation is applied again to make the right lane back to the original position.

Fig.4 shows the right lane recognition result. The left part of the result image is inverted non-recognition image and the right part of the result image is the inverted recognition image.

Algorithm Comparison

The whole image could be obtained through jointing the left and the right part. Fig.5 shows the whole result image. The traditional algorithm generally uses gradation and edge detection operation firstly; then applies the lane detection method basing on the Hough transform; at last obtain the lane from judging the particularity of intercept. Fig.6 shows the result processed by the traditional algorithm. The picture shows that the traditional algorithm regards the railing and another lane as the interested lanes. Both the error detections are caused by the out-of-flatness trait of target lanes. However the novel algorithm recognizes the target lanes correctly. This is because the processing procedure includes the remove of interference information and elimination of the error points.

Fig.5 Novel algorithm result

Fig.6 Traditional algorithm result

Traditional algorithm and novel algorithm are also applied in several images whose lanes could be recognized accurately. Table 1 shows the average processing time. It can be concluded that the novel algorithm shortens 45.3% of the processing time. This is because the novel algorithm contains the judgments and eliminations of the interference and redundant information.

Table 1 Average processing time

Algorithm	Traditional algorithm	Novel algorithm
Processing time [ms]	34.9	19.1

Summary

A revised lane detection algorithm was discussed basing on the modifications of traditional algorithm. This algorithm contains two parts: image pretreatment and lane detection. During the image pretreatment part, histogram equalization and morphologic processing are added. The histogram equalization solves the discrimination problem caused by different illuminations; the morphologic processing shields the interference and redundant information. During the lane detection part, left and right lanes are recognized by dividing the image into two parts. And this part adds the method of eliminating the interference of lanes out-of-flatness. At last, the results show that the novel algorithm can achieve higher accuracy and real-time performance.

References

[1] Takahashi, Arata, and Yoshiki Ninomiya. "Model-based lane recognition."*Intelligent Vehicles Symposium, 1996., Proceedings of the 1996 IEEE*. IEEE, 1996.

[2] Ma, Bing, Sridhar Lakshmanan, and Alfred O. Hero. "Simultaneous detection of lane and pavement boundaries using model-based multisensor fusion."Intelligent Transportation Systems, IEEE Transactions on 1.3 (2000): 135-147.

[3] Loose, Heidi, Uwe Franke, and Christoph Stiller. "Kalman particle filter for lane recognition on rural roads." Intelligent Vehicles Symposium, 2009 IEEE. IEEE, 2009.

[4] Yu, Hongfei, et al. "Lane recognition based on location of raised pavement markers." Intelligent Vehicles Symposium (IV), 2011 IEEE. IEEE, 2011. [5] P.G. Clem, M. Rodriguez, J.A. Voigt and C.S. Ashley, U.S. Patent 6,231,666. (2001)

[5] Franks, U., H. Loose, and C. Knoppel. "Lane recognition on country roads." Intelligent Vehicles Symposium, 2007 IEEE. IEEE, 2007.