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The Research of the Lane Detection Algorithm Base on Vision Sensor

Li Sha Sha
College of Automation, Harbin Engineering University, Harbin, Heilongjiang 150001, China

Abstract: The intelligent vehicle is an important area country in recent years of painstaking research in Intelligent Transportation System, which become the focus of the study, based on the visual structure of the road environment recognition. Aiming at the robust and real time problems of lane detection in the visual navigation system of intelligent vehicles, a robust lane detection method is proposed for the structured road. It can provide for intelligent vehicle automatically to maintain lane and changing lanes traveling lane information necessary to make smart vehicle to achieve a smooth, safe driving. Due to the complexity of the road itself, the complexity of the road image, Therefore, the pre-road established certain assumptions and these assumptions and the detection algorithm is combined to further improve the algorithm efficiency. Simulation test of the collected road images results show that the lane detection method designed in this study is stable enough to show the lane Position for engineering application not matter in good or poor illumination road condition.

Keywords: Hough Transform, lane detection, lane tracking

INTRODUCTION

The intelligent automobile is an important research field in the world recently (Rafer and Richard, 2002; Bertozzi *et al*., 2002). The system can provide information such as collision warning for motorists, advanced parking assist, lane keeping assist, lane change assist, driver monitoring and so on McCall and Trivedi (2006) and Dean *et al*. (1997). Moreover, it is an important task to study the lane detection of the structured road. The lane snatch is one of the most important aspects in the lane detection and lane recognition, which can provide the necessary information when the automobile is travelling (Baber *et al*., 2005; Guan-Lan *et al*., 2007). We take advantage of the information to complete automatic drive smoothly and safely. The application background is the highway or the standard high-grade highways and city roads. According to the lane of the structured road, the research on the algorithm of lane snatch will be launched in this paper. So it will offer some effective technologies for the stray warning system of automated driving.

THE PROCESS OF LANE SNATCH

The lane snatch system consists of two main parts: the computer and the camera. A camera affixed above the windshield of an automobile can captures the lane image which is taken as the input of system. Relevant information of lane can be extracted when the input image passed through the image pretreatment module and then the accurate lane will be acquired by the detection module.

Image pretreatment module is the key module of the system of lane detection. After image pretreatment processing, the binary can be acquired. Finally, the lane can be obtained in the binary image by the detection module.

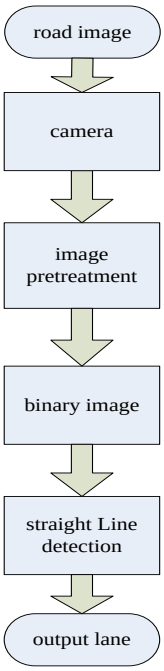

Fig. 1: The diagrammatic sketch of the lane detection system

The diagrammatic sketch of the lane detection system as shown in Fig. 1.

THE PRETREATMENT OF ROAD IMAGE

Because of the original image is easily affected by the noise in the road image processing and the real time

requirement of system, it is necessary that we have to preprocess the original image from camera. In our research processing, image enhancement, image filtering, edge detection included in the pretreatment of image. Removing the effect of noise on system and binarization are the primary mission in the pretreatment processing.

Image enhancement: The primary destination of the image enhancement is to improve the image quality. We can adopt some technology to stress a part of useful information and to weaken or remove some irrelevant information.

Gray level transform is a simple, effective, practical method which can amplify the image dynamic range, expend the image contrast, clear image, stress image feature and so on Zhi-Hong (2003) and Risack *et al*. (2000).

In the ordinary course of events, gray level of image is centered in smaller region, which obscures the clarity of image details. To improving the proportional relations of luminance so as to clear the image contrast, stress some target and enhance image. We adopt method of image histogram to achieve in this study.

A image is composed of n spots and the grey step is L, is the frequency of the k grey step, so the probability of the k grey step is:

$$\mathrm{p}_r(r_k) = n_k / n(0 \le r_k \le 1, k = 0,1,...,L-1) \quad (1)$$

The transformation function can be show as:

$$s_k = T(r_k) = \sum_{j=0}^{k} p_r(r_j)(0 \le r_k \le 1, k = 0,1,...,L-1) \quad (2)$$

We can figure out the gray value of each spots through statistical measure of source images histogram. According to the histogram of source images, we can figure out the gray value of each spots. In the balanced process, the dense part of grey-scale distribution will be stretched. On the other hand, the sparse part of grey-scale distribution will be condensed. Therefore, an image contrast will be enhanced overall.

The image contrast is not high on the cloudy or rainy days, so the divisions between land and background luminance is not obvious. We can adopt histogram equalization to improve image contrast. Figure 2 is the source image of lane. Figure 3 is the processed image through histogram equalization. It can be seen from the contrast of the image, the image contrast is significantly enhanced through histogram equalization. Be beneficial to the later image processing.

The color quantization: The road image is collected through the camera in this study. The original image is

Fig. 2: The source image of lane

Fig. 3: The processed image through histogram equalization

RGB color image. Considering the real-time detection of the road, we must to reduce the amount of calculation. Therefore, the color image information cannot be directly used to calculate in the road detection algorithm (Bertozzi *et al*., 2000; Tsugawa *et al*., 2001). The color image should be converted to grayscale. The luminance is divided into 0 to 25 of 256 levels generally, wherein 0 represents full black and 255 represents full white. From (0, 0 and 0) to (255, 255, 255), each one of the RGB values are identical. Due to the human have different visual sensitivity in color, three colors: red, green and blue, if mixed together in the same proportion, cannot obtained the same gray value of the corresponding luminance. The large experimental dates show that the gray values can be more in line with the human visual with red 30%, green 59% and blue 11% mixed. We can see in formula (3):

$$\begin{cases} V_{gray} = 0.30R + 0.59G + 0.11B \\ R = G = B = V_{gray} \end{cases} \quad (3)$$

The processing results show as Fig. 4a and b.

The image filtering: Noise is one of the reasons to reduce the image quality which change image characteristic and becomes difficult in the lane line extraction. Therefore, the filtering is a commonly used method for noise reduction.

Median filtering is a nonlinear filtering. The concrete step: the neighborhood pixel values are neighborhoods. Its prominent advantage is to arranged from small to large, taking the middle value as the

Fig. 4a: The RGB color image

Fig. 4b: The grey image

Fig. 5a: The effect of median filtering with 3×3 template

Fig. 5b: The effect of median filtering with 5×5 template

output value of center pixel point in eliminate the noise at the same time, but also to prevent blurred edges. Figure 5a and b are the effect of median filtering with 3×3 template and 5×5 template.

Image edge detection: The edge is the most basic features of image which is the junction of a property and another property area, is the changing place of property in the area, is the place of the greatest uncertainty in the image and is the place where most of the image information. In the other words, the edge of the image contains a wealth of information. So the image edge detection has a key role in the primary

Fig. 6a: The grey image

Fig. 6b: The flow chart of solving parameters

treatment of computer vision system and is an important part of the image analysis and recognition.

The edge feature of road image can be detected with the image edge detection operator. The different road image processing results can be obtained through different operators. We can find the strengths and weaknesses of each operator for the road image under the different conditions by comparison. The experimental results show that the satisfactory results can be got under the noise with canny operator. It is adaptive for the system of lane detection.

This study will use the canny operator for extracting road image edge in the system. Then the binarization processing helps us to finish the feature extraction of road through threshold segmentation. Road image is a JPG format of 640 × 480. The processing result shown as Fig. 6:

Image binarization: Before the edge detection, the image should be become binary image. The primary purpose of binarization is that the image will be divided into a number of distinguishable regions mutually. Because of there is strong contrast between the lane and road area in the road image, image binarization can reduce the information of image and pick up the speed of further analysis. when the image is segmented with the threshold, the pixels of all gray value is greater than or equal to the threshold value are divided into a certain object, besides, the pixels of all grey value is smaller than the threshold value are excluded to the outside the object.

The lane line has a certain width, so there are a large number of line pixels in the image. The pixels in the white road line will be almost always retained if we adopt image binarization directly. In other word, detection burden will be increased in later calculations.

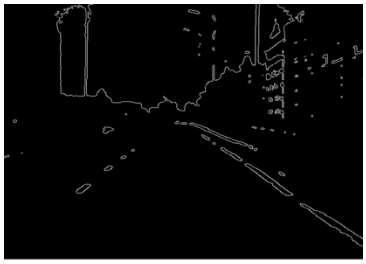

Fig. 7: Tracking results of the calibration line and the groove line (4 frames)

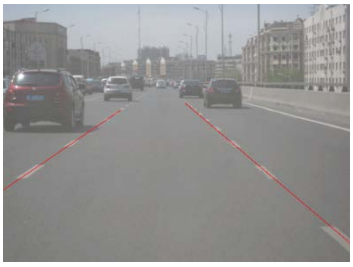

Fig. 8: The detection result of lane line (the red line is the result of detection)

Due to reduce the number of pixels, only the edge pixels in lane line to be processed which can propose the accurate information of lane line. Therefore, this study adopts binarization method based on the canny operator.

There are clear distinction between lane line and road. So the requirements can be met with global threshold method. In order to enhance system robustness and fit different environments such as cloudy or strong light, we have to slider control and binarization threshold variable are real-time connected in the program, the threshold can be dynamically adjust which achieve optimal extraction effect.

The Figure 7 shows the processing result of road image after binarization and then using Canny edge extraction. The experimental results show that the edge of lane line is maintained complete after binarization when the threshold is 198. The other part retains some scattered edge pixels which distribute in a muddle, so it almost does not affect the future of the line extraction.

LANE LINE EXTRACTION

A good detection algorithm of lane line should meet the conditions: accurately and perfectly detections: accurately and perfectly detecting the lane line information, analyzing the information truly, having certain robustness, meeting the real-time when the vehicle is running.

Therefore, after a series of pre-treatment for the road image, we have to analyze the road image binarized. The purpose of the analysis is that to extract information of the lane line in the image, but also that some information of straight line. The straight lane line is considered mainly in the lane line extraction algorithm. Fitting a straight line, there are two main ways: Hough transform and least squares method.

The method used by the extracting lane line is based on the above mentioned methods: Hough Transform, least squares method. According to the general installation of onboard cameras, the effective lane line generally concentrated in the lower part of the image of the camera's field of view. Therefore, the region of interest is set at the lower portion of the image. And there is little or no information of the lane line within the top region of image. The image point in those regions is excluded outside the interesting region of image. The detection result of lane line shown as Fig. 8:

CONCLUSION

The image processing and detection algorithms are studied in this study. After the image preprocessing, Hough transform is used for detecting lane line, the final result will be fitted with least squares method finally. Extensive experiments in variable occasions are implemented to prove the approach to be both robust and fast, besides, the algorithms can extract the lanes accurately even under unsatisfactory road situations.

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