A Fast Lane Detection and Tracking Algorithm

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Abstract: To improve the real time performance and robustness, an algorithm about lane coordination detection is proposed. The lane parameter is detected by the local windows extraction and the global extraction based on Hough transformation, with the help of the lane parameter confidence interval and the active box of interest. The algorithm is conducted including the below steps. First, set two groups of active boxes of interest; second, filter directionally; third, scan the number of lines in the interest box. The candidate points are selected to fit a straight line if the points have the max gradient. The experimental results show that the proposed scheme is accurate, robust and fast enough for the requirements of real time.

Introduction

In the lane migration system, the precision and speed of the lane line detection are the most important. In recent years, for the lane line visual detection problem, researchers have proposed many different algorithms, such as the method based on feature and the method based on model. Through the analysis of image low-level features such as edge, the method based on feature can split out the road from the image, and recognize the lane line [1-2]. Lane line can be described by a small number of model parameters, if the shape of the lane line is a straight line or parabola and calculation process of the model parameters can be seen as the process of lane detection [3-4]. Due to the interference of the vehicle, shadow, water and other factors, the method based on the characteristics is only applicable to such a situation that the road surface is clean and the light is good. At the same time, this method can not eliminate the interference of vehicles or noise. Although the model-based method has stronger robustness than that based on feature, but because of onerous computation and complex parameter optimization, the method is difficult to meet the real-time requirements of the intelligent vehicle navigation.

Under the low speed environment, the camera preview distance doesn't need to be too great. Within a certain foresight, the road can be considered to be linear, so the linear model is adopted. Coordinating the global parameters extraction of lane line based on Hough transform and the local parameter extraction of lane line based on least square fitting, the time detecting lane line is reduced.

The overall algorithm of the lane line detection

First of all, it needs to determine whether the collected image is the first frame. If it is the first frame image, the image is preprocessed. The left and right lane lines are detected by using the lane line extraction algorithm based on Hough transform. Otherwise, the left and right edges are processed by using two groups of interested active box to extract candidate and to fit a straight line. Then, the calculated lane line slope of the current frame is compared with that of the last frame. If

the results do not meet the requirements of the confidence interval, the system will put the next frame image as the first frame to deal with and reuse lane line extraction algorithm based on Hough transform to detect the lane line. The above process is shown as Fig. 1.

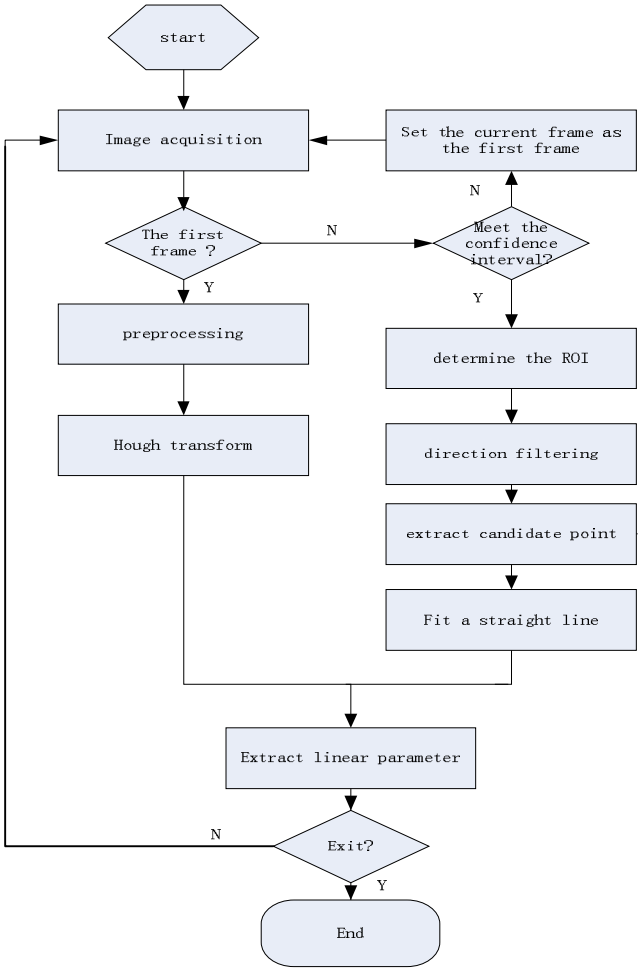
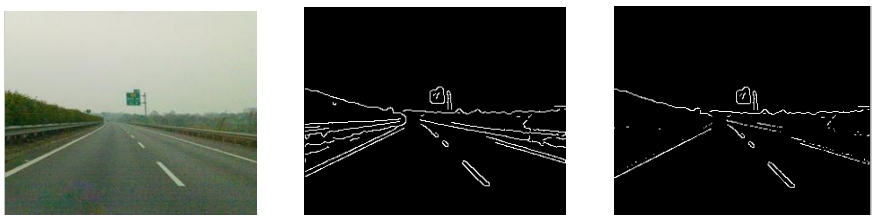


Fig. 1 Overall algorithm flow chart

Lane line detection

Image preprocessing

First, the collected image is processed by graying and median filtering. Then the edge image is obtained by canny edge detection. There is often a lot of useless edge information on both sides of the road. If all the edge information is dealt directly with, it can cause unnecessary operations and bring more difficulties to road detection. Cutting edge noise can filter useless edge points. The effect of the edge noise suppression is shown in Fig. 2.



(1) the input image (2) edge graph (3) the edge inhibition of figure

Fig. 2 the effect of the edge noise suppression

The extraction of straight line

Hough transform is as a result of the straight line segments, and the non-road line segments are more than the road line segments. Lane boundary can be selected from a line segment set by using a set of constraint condition.

Relative angle constraint

The actual situation of traffic can get the following assumptions:

1> Car is in the driveway;

2> Angle that the car is relative to the lane line is in a reasonable range;

Based on the above assumptions, line segments describing the lane boundary are limited in the scope of the general location and slope in the image coordinate system. If the slope of straight line is between k_{min} and k_{max}, it may be the lane line; otherwise the line segment is interference.

Interframe continuity constraint

The slope and intercept can determine a straight line. The interframe continuity of lane boundary requires that the change of the slope k and intercept b between two adjacent frames is in a reasonable scope, which is shown in equation (1):

$$\begin{cases} \left| b_i - b_{pre} \right| < \Delta b_{\max} \\ \left| \arctan(k_i) - \arctan(k_{pre}) \right| < \Delta f_{\max} \end{cases} \tag{1}$$

In the equation, k_i and b_i are the slope and intercept of the i-th segment. k_{pre} and b_{pre} are the slope and intercept of the lane boundary. $\Delta\psi_{max}$ and Δb_{max} are the maximum tolerance variation of the slope and intercept.

Area and the length of the constraints

Area constraint, that is, when there are multiple line accords with a condition, choose the line closest to the central image as the lane line. Because the interference usually come from the outside area of road, choosing the line closest to the central image as a lane boundary is reasonable. Length constraint, namely length must meet the minimum value setted.

Lane line tracking

Interest area

In this paper, Interest area is selected by two groups of interested active boxes (ABOI) [8], which is shown in Fig. 3. Track road right edge ABOI by the following set of equations for iteration.

$$\begin{cases} x_j^R = x_{j-1}^R - h_{j-1}^R(1+l)(2k^R) - b_{j-1}^R(1-l)/2 \\ b_j^R = l\, b_{j-1}^R \\ h_j^R = l\, h_j^R \\ y_j^R = y_{j-1}^R - h_j^R \end{cases} \tag{2}$$

In the equation, x_j^R and y_j^R are the abscissa and ordinate of the left vertex of the j-th box of interest. h_j^R and b_j^R are the height and width of the left vertex of the j-th box of interest. x_0^R and y_0^R are the intersection point that belong to the right boundary and image boundary in the last frame. λ is the attenuation factor, generally between 0.6 ~ 0.95. k^R is the slope of the border on the right side of the road. The calculation method of left AOBI group is similar to the right.

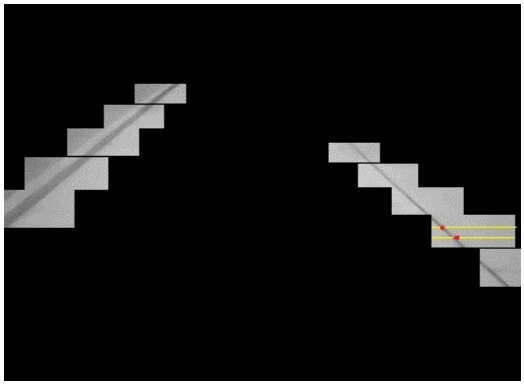
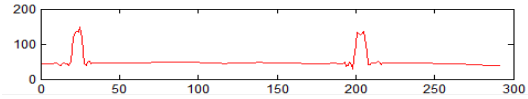


Fig. 3 Scannogram based on interest box

The selection of candidate points

Grayscale of road is usually evenly. The Lane line has high grey value relative to the road, as shown in Fig. 4:

(1) the input image



(2) the grayscale

Fig. 4 the grayscale of yellow line

The orientation filter

Because the relative to the road the lane line has high grey value, it can be detected by the method of threshold value. But when the light changes, the effect of this method is not ideal. So the lane line can be detected by the sensitivity to gray scale difference value. Direction gradient operator can satisfy this requirement. The effect of the direction gradient operator in 0 °、 45 °、 180 °、 135 ° is shown in Fig 5. It can be seen that 0 ° and 180 ° direction gradient operator in the 45 ° and 135 ° direction have very good effect; two kinds of the direction gradient operators can be used.

(a)The input image

(b) 0°

(c) 45°

(d) 135°

(e) 180°

Fig. 5 direction filtering figure in 0 °、 45 °、 180 °、135 °

Search in interested active boxes

After computing the gradient operator with the graphics, one-third and two-thirds of the line of interested active boxes is scanned, this is shown in Fig 3. A maximum gradient of points for a candidate in the scan line is selected. When the lane line is interval, some interest box may have not lane line, the extracted points are not needed. The gradient value of the point on lane line is more often than the gradient value of the point on non-lane line. A threshold value is settled, if the candidate gradient value is greater than the threshold, the point is extracted. Otherwise it is abandoned. The overall search steps are as follows:

Step1：Scan the line of the right interested active boxes, extract the 10 candidate points;

Step2：Compare grey value of 10 candidate points with threshold value, the point which grey value is greater than the threshold is filtered;

Step3：If the selected points are not less than two points, these points are linear fitted linearly. If the selected points are less than two, the current frame is settled as the first frame, and the next time process the whole image;

Step4：The process of the left side is same as the right;

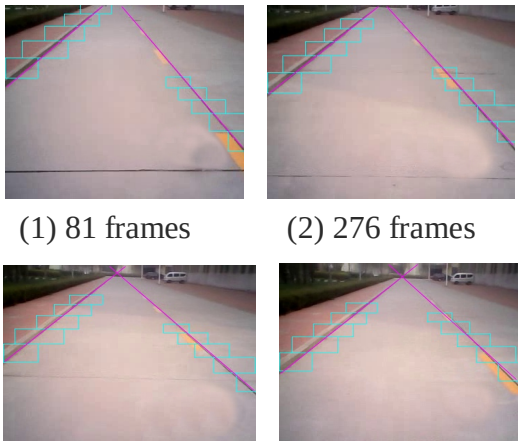
The confidence interval

The slope changes of two consecutive frames are generally in a certain range. If the slope changes of two consecutive are out of range, it can be considered that the detected line does not conform to the requirements. So the slope of the straight line k_1 of the current frame is compared with the slope of the straight line k_2 of the last frame. If $|k_1 - k_2| < \Delta k$, the extracted the lane line is practical lane line. Otherwise, the current frame is as the first frame and process the overall image.

The experimental results and analysis

The algorithm in this article is based on VC environment and OpenCV image processing library. Experiment is conducted on a road in the university, and 1000 lane frames in a video image sequence is intercepted and analyzed. After image processing, there are 976 images accurately detecting the lane line, the detection accuracy is about 97.6%. As a result of too big jump of lane line of the two consecutive frames or too serious interference information, the detection error appears.

Real-time is also one of the important indices for measuring algorithm performance. The image size processed in this paper is 352 x 288. It takes about 50 ms to operate the algorithm in the lane line detection link, and takes about 24 ms in the lane line tracking link. On average the time of every frame image processing is between 24 ~ 37 ms, so the algorithm can meet the demands of practical application.



(1) 81 frames (2) 276 frames

(3) 487 frames (4) 789 frames

Fig. 6 4 lane line extraction figure

Conclusion

This paper proposes a real-time method based on linear model to detect lane line. Due to the parameter confidence interval, active box of interest, and the coordination of global parameters extraction of lane line based on Hough transform and local parameter extraction of lane line based on linear fitting, real-time and robustness of the lane line detection is improved. Because edge

detection and Hough transform are effectively avoided in the tracking link of lane line, the running speed of algorithm is greatly improved. The experimental results show that for different road conditions, the algorithm proposed in this paper has better real-time and robustness.

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