A Lane Recognition System Based on Priority

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***Abstract*—Using OpenCV, a lane recognition system is designed. In this study, a lightweight approach is proposed to real-time detection of lanes using ROI (region of interest) based on priority setting. The traditional ROI is further divided into two regions of different priorities. The left line of the lane, detected in the left region, is given a higher priority. And it can deduce the other line of the Lane using camera calibration. It implements the fast lane detection and generation combined with Hough transform. Experimental results show the method has significant high output effectiveness. It reduces the time of image processing, and improves the real-time performance of the system. Even if the road information completely lost, the system could mark lane for temporary help.**

Keywords- Lane recognition; Region of interest; Hough Transformatio

I. INTRODUCTION

The car has become a more and more important tool in modern social life, At the same time, 1240000 people died in road traffic injury each year in the world. [1]In order to prevent traffic accidents, domestic and foreign researchers have done a lot of research work. Auxiliary driving is an important direction. As one of the most important functions of auxiliary driving, Lane recognition mainly includes two parts. One is Image prepreccessing, the other is Lane line extraction. This paper designs a lane recognition system using OpenCV. In order to improve the real-time performance of the system, we proposes a lightweight approach to real-time detection of lanes using ROI based on priority setting .

II. PRE-PROCESSING

Wherever Times is specified, Times Roman or Times New Roman may be used. If neither is available on your word processor, please use the font closest in appearance to Times. Avoid using bit-mapped fonts if possible. True-Type 1 or Open Type fonts are preferred. Please embed symbol fonts, as well, for math, etc.

Road image preprocessing is an important work before the road detection and recognition. The main purpose is to remove a lot of mixed noise ,to save the useful information of the pavement, to enhance the delectability of useful information and so as to improve the reliability of detection and recognition. Pre-processing includes gray processing, smoothing filtering, edge enhancement and two value image.

1）gray processing

Due to color image contains a large amount of information, the speed of direct processing is slow. So we generally use the identification method based on the gray level features.

In our design, RGB is the color model of video image. Grayscale image conversion needs to quantify the brightness values. A large number of experimental data show that the effective luminance of a pixel is calculated with the following formula.

$$\begin{cases} V_{gray} = 0.30R + 0.59G + 0.11B \\ V_{gray} = R = G = B \end{cases} \tag{1}$$

Using cvCvtColor,the OpenCV function,we could convert color image to gray image. The function parameter is set to CV_BGR2GRAY, In this way, the multi-channel image is converted to a single channel image.

cvCvtColor(m_pFrame,pFrImg, CV_BGR2GRAY); // convert to single channel Firstly

Gray processing effects is shown in Figure 1.

Figure 1. (a) The original image；(b) The gray scale image

2）Smoothing filtering

Smoothing technique is used to smooth the image noise. Smoothing noise can be performed in the spatial domain by calculating the pixel gray average or median as the basic method. We also can use a low-pass filtering in the frequency domain.

Because the frequency domain filtering requires a relatively large amount of computation, it is not suitable for application in vehicle vision system. The spatial filtering method used in this paper.

The design adopts Gauss filter to smooth the image with 5*5 template.

```
cvConvert(pFrImg, pFrMat);
cvSmooth(pFrMat, pFrMat, CV_GAUSSIAN, 5, 1, 0);
    // Gauss filter
```

3）Edge enhancement

The main purpose of the image edge processing is the highlight image details or enhance the blurred details, so as to demonstrate the structure of scene clearly .Because the image edge are located with gray mutation , so the image edge detection is based on the differential effect. The method is mainly based on various differential operators. Common operators are Sobel operator, Robert operator and Laplace operator.

The Sobel operator template as follows,by $0°, 45°, 90°, 135°$ directions.

$$\begin{bmatrix} -1 & -2 & -1 \\ 0 & 0 & 0 \\ 1 & 2 & 1 \end{bmatrix} \quad \begin{bmatrix} -2 & -1 & 0 \\ -1 & 0 & 1 \\ 0 & 1 & 2 \end{bmatrix}$$

$$\begin{bmatrix} -1 & 0 & -1 \\ -2 & 0 & 2 \\ -1 & 0 & 1 \end{bmatrix} \quad \begin{bmatrix} 0 & 1 & 2 \\ -1 & 0 & 1 \\ -2 & -1 & 0 \end{bmatrix}$$

The local average of Sobel operator, can not only affect the image edge detection but also suppress noise further. Weighted local average method makes the edge thick and suitable for lane detection.

Design using cvOpenCV function to handle.

The treatment effect is shown in Figure 2.

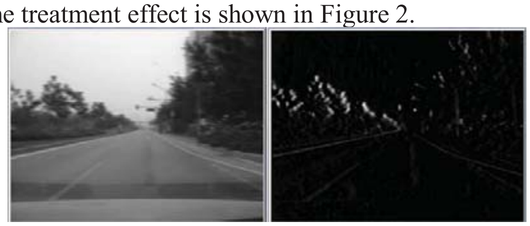

Figure 2. Image contrast

Figure 3. Edge enhancement and sharpening

When the effect of edge detection is analyzed, we could sharpen image to display the edge effect. The original image and edge detection image are added to get the sharpening image.

After edge enhancement, the results are represented in fig.3.

4）Threshold

If there was significant difference between the object and the background, as long as the appropriate threshold is selected, and through values of two treatment or half value processing, the object could be separated from the background.

If the original image is $f(x,y)$, the threshold T is selected through the use of appropriate methods.

The steps of the algorithm for threshold T of every frame image are following as:

Step1, calculate the maximum threshold of the pixels in the image and the minimum threshold;

Step2, calculate the average Zave of the Zmax and Zmin, Zave=(Zmax+Zmin)/2;

Step3, calculate the average value(Z0) of the pixels, which are less than Zave in the image. And then calculate the average value(Z1) of the pixels ,which are larger than Zave in the image.

Step4, calculate the average value of Z0 and Z1,Zopt=(Z0+Z1)/2.Then take Zopt as the image threshold T.

Through the above steps we obtain the best threshold T, and use T for image two value processing.

$$g(x,y)=\begin{cases} 1 & f(x,y)>T \\ 2 & f(x,y)\le T \end{cases} \qquad (2)$$

The key link is the threshold selection. Thresholding methods are commonly used such as gray difference histogram , differential histogram , the 2-D maximum entropy ,fuzzy threshold segmentation method etc..

In the design, we call cvAdaptiveThreshold(),which is the threshold processing function and belongs to OpenCV. There may be two different adaptive threshold method by setting the parameter adaptive_method, include The Adaptive Mean threshhold and The Adaptive Gauss threshold.

The parameters of the system are set as follows.
adaptive_method=CV_ADATIVE_THRESH_MEAN_C, threshold_type=CV_THRESH_BINARY, maxValue=255, block_size=3, param1=5.

The size of “block_size“ neighborhood must be odd; “Param1“ is a specified constant.

5）ROI

Because the camera installation position is stationary in the car and the road information captured is in the relatively narrow range, we divide the road information to remove the influence of the sky and trees.

Set the whole image size is S.Refer to [6-9], then the size of the ROI is ROI=7*S/12.

A1 is the main region of sky, basically does not contain Lane information.A4 is the front of the car and the projection information. So A1 and A4 can be excluded from the region of interest in the detection of Lane, and we could extract lane line only in A2 and A3 range.

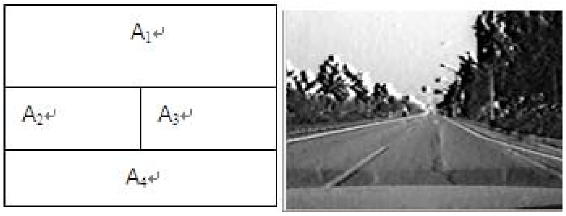

Figure 4. The division of ROI

It is nessary to set A4 to fulfil the system demand of "driving record function".

Video contains the information,so as to record more comprehensive information in driving process.

Threshold processing images as shown in figure 5.

Figure 5. Threshold processing

III. LANE RECOGNITION

Most of the roads are structured, and have strict standards. So the lane near field area can be approximated as linear within the prescribed speed. Hough transform is one of the most commonly used method in the lane line extraction algorithm. Hough transform is a mapping from the image space to the parameter space,as shown in the formula (3).

$$\rho = x\cos\theta + y\sin\theta \qquad (3)$$

Where ρ is the normal distance from the line to the origin. θ is the angle between the normal and the X axis. In this way, a bit of road image plane corresponds to a curve of parameter plane. According to the dual rule, if some edge points given in road image, we can determine the line connecting these edge points by Hough transform.

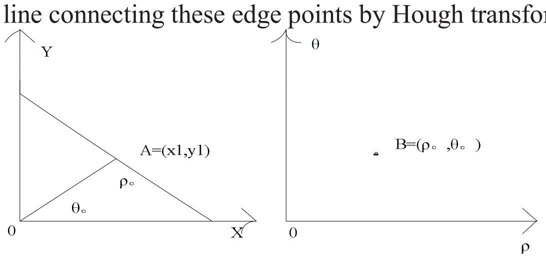

Figure 6. Transform Cartesian coordinates to polar coordinates

In the design, we call cvHoughLines2 () to achieve Hough transform to find the line in the binary image. Where Param1, param2 are respectively used for probabilistic analysis of the length and spacing. The function is defined as follows.

CVAPI (CvSeq*) cvHoughLines2 (CvArr* image, void* line_storage, int method, double rho, double theta, int threshold, double param1 CV_DEFAULT(0), double param2 CV_DEFAULT(0));

Changing the value of the last three parameter will change the effect, After debugging, we choose 20,10,20 as values of the last 3 parameters, and obtain better visual effect. Finally, we use the cvGetSeqElem () and cvLine () function to mark the detected lane . Figure 7 shows the results of our test.

Figure 7. Lane recognize and mark in ROI

IV. OPTIMIZATION

Condition 1. Road is the standard grade two or above, with 3.75 lane width.

Condition 2.The car camera is in the middle position, has been fixed.

Condition 3. Camera calibration has been completed

Based on the above conditions, we can set the priority level in the ROI. Video area A2 is the first high priority.A3 is the second priority. Algorithm design is as follows.

Step1.Detect lane markers in the current video frame(i) in the A2 region，If the left lane line is recognized , then mark it as the first priority and goto step2.If it is not recognized ,then direct into step3.

Step2. According to the results of the first step, generate the right line in A3, and mark it as the second priority. Match the current lane markers with those detected in the previous video frame based on priority.

Step3. Detect lane markers in the current video frame(i) in the A3 region, If the right lane line is recognized , then mark it as the first priority and goto step4.If it is not recognized ,then direct into step5.

Step4. According to the results of step3, generate the left line in A2, and mark it as the second priority. Match the current lane markers with those detected in the previous video frame based on priority..

Step5. If both of the two regions were not detected the lane line, according to the current driving condition ,we should give lane marker for temporary help.

Flow chart is shown as follows Fig.8.

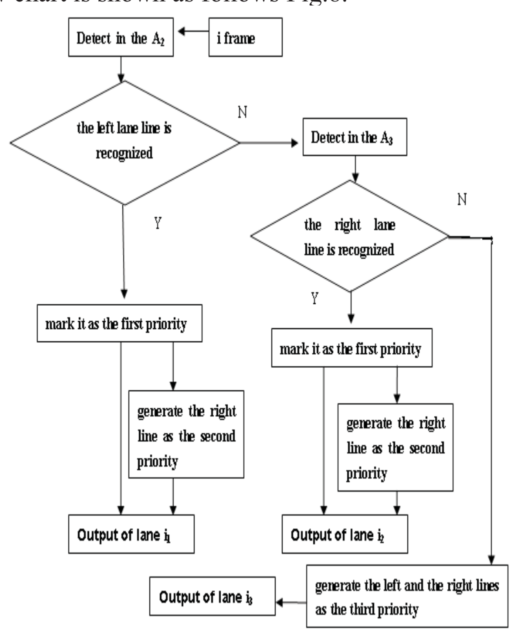

Figure 8. Algorithm flow chart

A treatment cycle consists of 20 frame

OpenCV calibration method is used to complete computer calibration.

The camera parameters are as follows.

Focal length fc:[810.23555 802 803.26538] (mm/p);

Datum mark u0:376.533 (mm/p) v0:198.073 (mm/p);

Deformation coefficient K1=-0.19403 ,K2=0.1251, P1=-0.00196 P2=-0.00332.

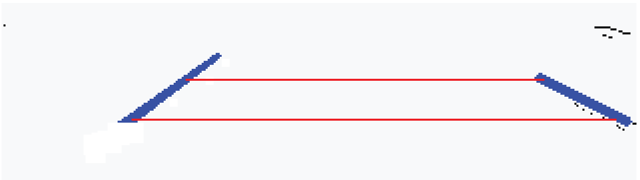

Figure 9. Schematic diagram of lane generation

V. DATA COLLECTION AND EXPERIMENT

We realize the lane recognition based on OpenCV by Visual C++6.0. A single camera is used to collect video from Beijing Chaoyang North Road. The data is stored as a 32-Bit RGB AVI file ,which is about 25 minutes long. The testing environment includes WINDOWS XP SP2,CPU2.01GHz and Memory1.87G.We use the ROI algorithm and ROI algorithm based on priority to test the avi file, which is divided into 100 videos. Each video last about 15 seconds.

The road for testing is in the same horizontal plane, and is defected seriously about lane lines in some sections road in testing time (2013) . The testing car is in a stable driving state. The artificial detection results as the standard, we compare the results before and after optimization, as shown inTable1 and Table2.

TABLE I. THE LEFT LANE

The Left Lane line	Recognized	Output	Correct output
The original algorithm	70	70	70
The optimized algorithm	70	100	93

TABLE II. THE RIGHT LANE

The Right Lane line	Recognized	Output	Correct output
The original algorithm	61	61	61
The optimized algorithm	19	10 0	93

VI. CONCLUSION

Lane recognition system based on OpenCV is feasible, and this system may fully meet the design requirements, it has good effect in the practice. The algorithm, which set ROI, can greatly shorten the processing time. And when the ROI is set priority to optimization, nor only the real-time performance of the system is improved, but also a high robustness is maintained. Even if the road information completely lost, the system performance is good, and has the practical value.

REFERENCES

[1] Global Status Report On Road Safety 2013,World Health Org., Geneva,Switzerland. 2013, [Online]. Available: http:// www.who.int/violence_injury_prevention/road_safety_status/2013

[2] Jin Hui,Wu Lelin,Chen Huiyan,Gong Jianwei. "An Improved Algorithm for the lane Recognition of Structured Road", Transaction of beijing Institute of Technology, vol. 27,pp. 501-505,Jun 2007

[3] Yu Bing,Zhang Weigong,Gong Zongyang."Lane departure waring system based on machine vision".JOURNAL OF SOURTHEAST UNIVERSITY(Natural Science Edition), vol..39,pp.928-932,May 2009

[4] Shen Huan,Mao Jianguo , Li Shunming."Monocular Camera Machine Vision Lane Recognition Algorithm and Realization on ARM System".Journal of Nanjing University of Aeronautics &. Astronautics. vol. 40,pp.209-213,Feb2008

[5] Luo Caibin,Hu Qingxin,Wu Lincheng."A judgment method of lane extension direction for speedway", JOURANL OF HEFEI UNIVERSITY OF TECHNOLOGY, vol.34,pp.857-891,Jun 2011

[6] KIMZW. "Robust Lane Detection and Tracking in Challenging Scenarios".IEEE Transactions on Intelligent Transportation Systems,2008,9(1),pp.16-26

[7] LEE J W, YI U K. A lane-departure identification based on LBPE, Hough transform, and linear regression Joon.Computer Vision and Image Understanding,2005,99(3),pp.359-383.

[8] Suchitra Sathyanarayana,Hierarchical Additive Hough Transform for Lane Detection . IEEE Embedded Systems Letters June 2010,2010,2(2),pp.23-26

[9] Joel C. McCall and Mohan M. Trivedi.Video-Based Lane Estimation and Tracking for Driver Assistance: Survey, System, and Evaluation[J]. IEEE TRANSACTIONS ON INTELLIGENT TRANSPORTATION SYSTEMS, 2006,7(1),pp. 20-37.

[10] Shi Xiaopeng,He Wei,Han Liqun.A road edge detection algorithm based on the Hough transform .CAAI Transations on Intelligent Systems.2012.1(7),pp.81-85

[11] Yin Wensheng,Luo Yunlin,Li Shiqi. Camera calibration based on OpenCV Computer Engineering&Design.2007,28(3):197-199.

[12] Shen Yun,Luo Weiwei,Wang Xiaopeng,Lei Tao.Linear model based lane mark identificational gorithm.Application Research of Computer. 2011.4(28),pp.1544-1550

[13] Zhang Zhengyou. A flexible new technique for camera calibration[J]. IEEE Transactions on Pattern Analysis and Machine Intelligence, 2000 , 22(11),pp. 1330-1334

[14] J.C. McCall and M.M. Trivedi. Video-based lane estimation and tracking for driver assistance: survey, system, and evaluation. IntelligentTransportation Systems, IEEE Transactions on, 7(1),pp.20–37, March2006

[15] Hong Wang and Qiang Chen. Real-time lane detection in variousconditions and night cases. In Intelligent Transportation Systems,Proceedings of the IEEE, pp. 1226–1231, Sept. 17-20, 2006

[16] Zu Kim. Realtime lane tracking of curved local road. In Intelligent Transportation Systems, Proceedings of the IEEE, pp.1149–1155,Sept. 17-20, 2006.

[17] JIA Lishan,Luo Jian,LI Shiqi. Road curvature estimation based on linear lane model[J]. Journal of JIangsu University(Natural Science Eidt, 2012, 33(4):,pp373-378