全局灰度可以很好地用于确定图像的亮度。如果图片强烈亮，则直方图均衡对于图像增强特别有用。相反，灰色拉伸是为了增强弱亮图像。为了缩小车道检测范围，找出车道的上限，同时确认极角约束。->为了识别车道曲线，基于前一步骤中由霍夫变换检测到的信息。首先，将感兴趣区域分成五部分，对每个部分执行霍夫变换部分，一些小线段通过相应的变换，线段的每一部分都是成对的，一对线的交点会产生多个交点。通过投票选择消失点。确定消失点，确定各区段的小线段并选定区域，确定车道的整体坡度。关键帧由每个帧的总梯度值选择。根据小直线段，利用灰度分布找出车道中心，最后用B样条曲线拟合车道线-
->根据车辆视频图像的道路结构特征，建立车道检测的极端角度约束条件，以缩小车道检测范围。->A.找到道路的顶部边界　具体做法是从灰度图像的顶部（或底部）开始，逐行累加像素的灰度，并通过极值搜索算法进行极值计算。设灰度图像为M×N维矩阵，并设置阈值TS。让两个变量累加r1和r2。 r1用于存放最后一行的累计值，r2用于存放当前行的累计值，当累加一个新值时，r2的值将被转储到r1，新的值将存储在r2中，然后将r1和r2之间的差值存储到变量d中。当d大于Ts时，相信积累的线是潜水线。这种方法的准确性很大程度上取决于阈值选择，因此选择合理的Ts是很重要的 ->极地禁闭区　在道路图像中，车道线分布在图像的两侧，大量实验证实了所有车道线的角度都包含在特定区域中，我们称之为该区域的极限约束区->通过设置极角约束，减少了边缘点的数量和 θ 的范围，并且Hough变换检测线的计算减少了50%，大大提高了运算速度，减少了线性噪声的影响->C.动态ROI　感兴趣区域也被称为ROI区域。 每秒可拍摄25张图像。 在两幅相邻图像之间提取的车道图像是精确的，这意味着两幅相邻图像中车道线的位置偏差不是很大。 根据车道线的检测，划分出ROI区域，然后在ROI区域下一帧检测车道->在车道检测过程中添加车道线检测失败。 当算法无效时，Hough算法将用于检测车道。 算法失败的条件如下：如果从当前帧检测到的车道参数相对于前一帧发生变化。 在动态ROI中，霍夫变换检测到的行数为零。 泳道线的置信度（包括倾斜度，平行度等）低于置信度指数。->在提取感兴趣的区域之后，场景被分成五个部分。 首先利用Hough变换在各部分中提取初步车道，然后利用线性逼近原理估计车道延伸的方向和区域，提取车道边界点。 在车道边界点的基础上，通过B样条曲线重建车道线。 ->图像被分成五部分，图像部分的高度随着移动到图像的上部逐渐减小，并且在每部分中使用霍夫变换用于线条检测->用于线检测的变换。由于梯度值的变化越小，车道信息越少，区域越小，这个地区会更小。 所以我把图片从上到下放到1/8，1/6，1/4，1/3，1。随着移动到图像的上部，图像部分的高度逐渐减小。 然后使用霍夫变换来提取每个区域中的直线。 请注意，每个图像部分都有自己的线参数空间，并且每个图像部分中的边缘点分别针对该部分中的可能直线进行投票。 通过对归一化累加器空间进行适当的阈值处理，可以针对每个图像部分最终检测线段。->在每个区域中，线条都是成对绘制的，并且计算每对线条。 在原始算法中，交叉点不具有相应的权重。 在这个算法中，每个节点都有自己的权重，权值是相关区域的长度。->灰度分布。 车道线的典型横截面显示单峰特征。 每行的中点选择峰值区域作为车道线行程点，行扫描得到每条线的中点坐标。然后用Hof变换检测由中点形成的最长直线，直线为由灰度分布检测的最后一行。->灰度分布。 车道线的典型横截面显示单峰特征[18]。 每行的中点选择峰值区域作为车道线行程点，行扫描得到每条线的中点坐标。然后用Hof变换检测由中点形成的最长直线，直线为 用作如图8所示由灰度分布检测的最后一行。->C.连续的帧错误改进　首先进行图像分割，Hough变换处理，得到消失线，并确定每个区域的消失点。 将下端区域的下端设为P，将上端区域的上端点设为P，将两点连接起来求出线性方程式。->，当前是否被识别为关键帧。 如果存在，则确定当前车道和关键帧的差异过大，如果过大，则确定关键帧。 关于谭的原则并不是0.1结果之间的区别。如果不是，请保留当前关键帧。 根据投票原则确定帧，按照下式计算当前帧上的五个通道：1，从©2，©3，©4，©计算最后一帧的平均值作为密钥的平均值 框架，关键帧的车道线拟合，输出车道。 然后为每个框架重复上述步骤。 此方法确保车道线在没有发生重大变化时，输出相同的车架保持车道线，以确保用户的视觉效果。

***Abstract*—In modern society, with the economic conditions getting better, more and more vehicles are produced. So many vehicles bring about the rapid development of traffic transportation and the traffic accidents happen frequently. With the fast development of computer technology, more and more interests are focused on vision navigation technology in Intelligent Vehicle System. At the same time, lane detection is an important component of intelligent vehicle vision navigation system. In order to improve the real-time detection, an improved lane boundaries detection based on dynamic regions of interest is presented. The approach is an essential tasking both autonomous lane vehicles research and active safety system development. Lane detection is, however, still a challenging issue due to the complexity of the real road scenes. Our approach takes advantage of the image preprocessing with different processing on the images with different illumination, ROI decision algorithm and lane detection based on the vanishing point and Hough transform. The achieved results reveal that the Hough transform with the dynamic ROI algorithm and vanishing point method is more effective.**

Keywords-lane detection; hough transform; dynamic ROI

解决由于环境变化，例如阴影，车辆遮挡，磨损标记，车辆自我运动，变化的照明条件和其他图像伪影。这些问题

Lane boundaries detection has broad applications in future autonomous vehicles and intelligent transportation systems as an important component of scene understanding [1]. The most typical example of this is the lane departure warning system that acts when the car is driven out of a lane inadvertently, and in which vision-based lane detection algorithm is a fundamental step [2]. In fact, several researchers worldwide have proposed many vision-based methods for lane detection. At present, some developed countries have successfully developed a number of road detection and tracking based on vision sensor System. ALVINN System, SCARF System, RALPH System, GOLD System and LOIS system are representative. Yue using the B-Snake spline as a template for lane detection and tracking, the precondition of this method is to use CHEVP to get some correct parameter template, and then use B spline interpolation and energy minimization method for lane line fitting, but this method has obvious defects, especially for the line type and lane road is more complex scenes. Get the correct parameters by using CHEVP not usually, which led to the subsequent lane detection step failed [3]. Amol Borkar lane detection in the paper make the image divide into two parts firstly, the left part lane detection and the right part lane detection. But this method cannot deal with mobile phone angle changes, the lane above extra information too much, so they do not have practical applications.

The research is active and extensive in intelligent transportation during the past decade. But there are many problems need to be solved in lane detection. However, the problems are not yet completely resolved because of environmental variability, such as shadows, vehicles occlusions, wearied markings, vehicle ego-motion, varying illumination conditions and other image artifacts [4]. In this paper, an accurate and effective lane boundaries detection method is proposed to tackle the above problem in this paper. The method is faster with higher accuracy. With the aim of describing lane shape, some new algorithms are used in lane detection. In image preprocessing, global gray scale is perfectly used for determining the degree of brightness of the picture [5]. If the picture is strong bright, a histogram equalization is particularly useful for image enhancement. On the contrary, gray stretching is adapted to enhance the weak bright image. For narrowing the lane detection range, finding the upper bound of lane, at the same time, confirming the polar angle constraint. This process is a dynamic detection process. In the process of identification, in order to identify lane curve, on the basis of the information that has been detected by the Hough transform in the previous step. Firstly, the region of interest is divided into five parts, Hough transform is performed on each part, some small line segments through the corresponding transformation, each part of the line segments are in pairs, The intersection of a pair of lines gives rise to a number of intersections. Select the vanishing point by voting. The vanishing point is determined, the small line segments of each section can be

在图像预处理中，全局灰度可以很好地用于确定图像的亮度[5]。如果图片强烈亮，则直方图均衡对于图像增强特别有用。相反，灰色拉伸是为了增强弱亮图像。为了缩小车道检测范围，找出车道的上限，同时确认极角约束。这个过程是一个动态检测过程。在识别过程中，为了识别车道曲线，基于前一步骤中由霍夫变换检测到的信息。首先，将感兴趣区域分成五部分，对每个部分执行霍夫变换部分，一些小线段通过相应的变换，线段的每一部分都是成对的，一对线的交点会产生多个交点。通过投票选择消失点。确定消失点，确定各区段的小线段并选定区域，确定车道的整体坡度。关键帧由每个帧的总梯度值选择。根据小直线段，利用灰度分布找出车道中心，最后用B样条曲线拟合车道线

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根据车辆视频图像的道路结构特征，建立车道检测的极端角度约束条件，以缩小车道检测范围。

determined and selected area, determine the overall gradient of the lane. Key frames are selected by the overall gradient value of each frame. According to the small straight line segment, the gray level distribution is used to find the center of the lane, and finally the lane line is fitted by B- spline curve.

II. ROI DECISION ALGORITHM

Besides the lane information in the detection of the scene for lane detection, the overall picture content is more complex relatively. If detect the lane for the whole image, the calculation is large and easy to cause errors. In this paper, according to the road structure characteristics of the vehicle video image, the extreme angle constraint condition of lane detection is established to narrow the lane detection range.

A. Find the Top Border of the Road

According to researchers, the gray scale of region of the sky has an obvious different between daytime and dark environment such dusk time or night time [6]. Therefore, we can use following method to find out the upper bound of road.

极值搜索算法

Specific approach is that accumulation pixel's gray scale in each line from the top (or bottom) of a gray image, and get the extremum calculation through extremum seeking algorithm. Let gray image is an M*N-dimensional matrix, and set the threshold T_S. Let two variable of accumulation r_1 and r_2. The r1 is used to storage the accumulative value of last line, r_2 is used to storage the accumulative value of current line, when accumulated a new value, the value of r_2 will dumped to r_1, and the new value will storage in r_2, then storage the difference value between r1 and r_2 into variable d. when d is bigger than T_s, believe that the line which is accumulated is the diving line. The accuracy of this method is largely determined by the threshold selection, therefore it is important to select a reasonable T_s [7]. In our experiment, we found that there has an intersection of gray value's jump-value between different light environments. Through the theory analysis and experiment, using this method can get the jump-value line of gray value effectively, thus expecting a mount of useless zone of feature detection of lane line, and easy to understand and be realized. This algorithm has strong adaptability under different angles of the picture, images of different angles of view were detected as Fig. 1., Fig. 2. The left image is the original image, the middle is the picture with the upper bound of the original algorithm, and the right is the picture with the upper bound of the algorithm in this paper.

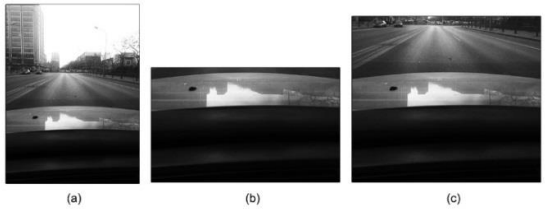


Figure 1. Top border detection result of the picture with low angle of view

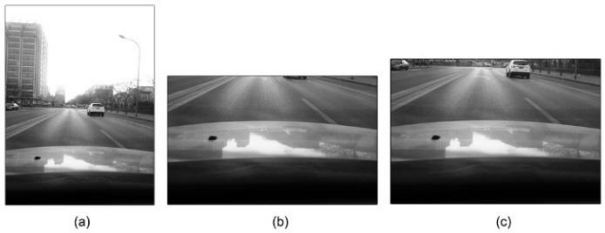


Figure 2. Top border detection result of the picture with normal angle of view

B. Polar Confinement Region

In the road images, the lane lines are distributed on sides of the image, a large number of experiments verify that the all angle of lane line are included in a specific area, we call this area polar confinement region[8]. As the polar confinement region in figure 3, for model (a) and model (b), the range of θ_1 is 30°～70°. For model (a), the range of θ_2 is — 20°～— 70°; for model (b), the range of θ_2 is 110°～160°, the range of θ_2 can be unified to 110°～160°.

By setting the polar angle constraint, the number of edge point and the range of θ are reduced, and the computation of Hough transform to detect the line is reduced 50%, it is improved the operation speed greatly, reduce the influence of linear noise, increase the detect rate of lane detection to a certain extent.

C. Dynamic ROI

Region of interest is also called the ROI region. 25 images can be captured by a camera a second. The lane images extracted between two sequent images is relative, means that the position deviation of lane lines in two adjacent images is not very large. According to the detection of the lane line, to delineate the ROI area, and then the next frame only detection lane in the ROI area as shown in Fig.3 [9]. By this means, it will track the lane with the narrower search area, and reduce program time. By the analysis of actual road image acquisition, continuous change of slope of lane two frames in the road image is about 3 degrees, the intercept change is about 10 pixels.

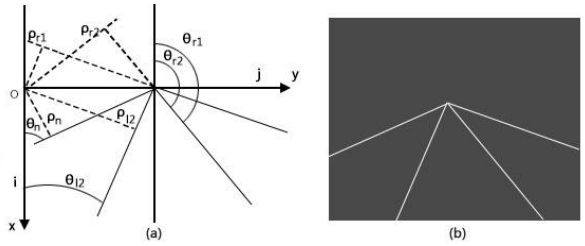


Figure 3. Lane recognition area

When the road image is seriously disturbed, such as lane change in the vehicle lane, and the turn based on the region of interest Hough transform track, are likely to produce greater error or even failure. According to this, the lane line detection failure is added in the lane detection process. When the algorithm is invalid, the Hough algorithm will be used to detect the lane. The conditions for the failure of the

algorithm are as follows: If the lane parameter detected from the current frame changes with respect to the previous frame. In dynamic ROI, the number of lines detected by the Hough transform is zero. Lane line confidence (including the inclination, parallelism, etc.) is lower than the confidence index.

III. LANE DETECTION BASED ON THE LINEAR-APPROXIMATION AND HOUGH TRANSFORM

In this paper, lane detection is accomplished with Hough transfer and linear-approximation. After extracting the region of interest, the scene is divided into five parts. Firstly extract the preliminary lane using Hough transform in each part. Then the linear approximation principle is used to estimate the direction and region of lane extension and extract the boundary point of lane. On the basis of lane boundary points, the lane line is reconstructed by B- spline curve. For the straight line in Descartes coordinate system, the Hof transform is transformed into the parameter space of the polar coordinate system by the formula of the transform.

A. Principle of Hough Transform

Hough transform is a fast shape matching technique which is used in edge joining widely, proposed by P. V. C. Hough in 1959 primitively[10]. It uses the global feature of the image to detect the target contour, and can be used to identify the geometry in digital image processing. For the straight line in Descartes coordinate system, the Hough transform is transformed itself into the parameter space of the polar coordinate system by the formula of the transform [11].

1) $\rho = x\cos\theta + y\sin\theta$

2) In the above formula, ρ is the distance from straight line to coordinate origin. $\theta\theta_i$ is considered to be the angle between a straight line and a horizontal axis. The linear Hough transform can be simplified to a point (ρ, θ) in polar coordinates [12]. The Hough transform performs the voting on the target shape in the parameter space of the polar coordinate system obtained from the transformation, the maximum (global or local) values are then searched in the voting parameters to obtain the area of the target shape. The completion of the Hough transform generally takes the following four steps:

3) The suitable parameter interval is selected to quantify the Hough parameter space.

4) To construct a sum matrix A (ρ, θ), the subscript of each element of the matrix corresponds to the position in the change space, and the value of the element is the number of curves passing through the point.as shown in Fig.4

5) If set the image point valued 0 as the background point, pixel value of 1 points for the target feature points, then use the voting strategy to find the points in the parameter space of these target points in the image space, and increase the element value of the corresponding position of the accumulated matrix by 1.

6) Peak point searching. The peak points in the accumulation matrix are generally corresponding to the target shape features in the image plane, and the size of the peak indicates the number of pixels on the corresponding curve. Thus the required features can be obtained by searching the peak points.

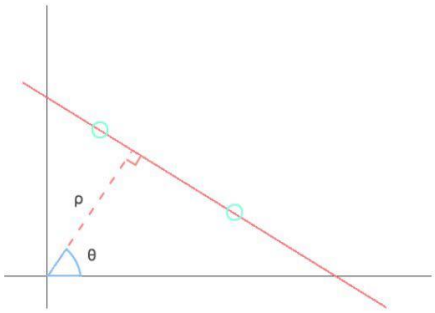


Figure 4. Hough transform

As a dimension in parameter space of Hough transform, angle information provides a convenient way to calculate the slope to each pixel in the image. Moreover, with the changing of the car's forward angle in main road, the slope which is output by the system will also be changed[13]. Building the relationship which can exchange the feedback timely in a one-to-one correspondence way, can make the preserve the accuracy of the results, accurately. As a consequence, the computational method of the lane slope by using Hough transform, can not only provide the high detection accuracy of lane line, but also avoid the complex parameter demarcating to the inside and outside of camera Because of the Hough transform is insensitive of the rotation of image, it has be widely used in image processing.

B. Determination of Vanishing Point

In the lane detection, due to the complex changes of light and traffic, the use of color lane detection is not robust and practical at the same time, the characteristics of parallel Lane Detection requires real-time manual calibration of coordinate points [14], also do not have the practical application, so this paper chooses the lane line detection using vanishing point.

1) The image is divided into five parts, the height of image section is gradually reduced as moving to the upper part of image as shown in Fig. 5, and in each part using Hough transform for line detection as shown in Fig. 5 .

Because the smaller the change of gradient value is, the less the lane information is, the smaller the region is, the smaller the region will be. So I put the picture from top to bottom into 1/8, 1/6, 1/4, 1/3, 1. The height of image section is gradually reduced as moving to the upper part of image. Then the Hough transform is used to extract the straight lines in each region. Notice that, each image section has its own space of line parameters, and edge points in each image section vote separately for possible straight lines in that section. By suitably thresholding the normalized

accumulator spaces, line segments can be finally detected for each image section.

Figure 5. Domain Hough transform

2) In each region, the lines are drawn in pairs, and each pair of lines is calculated. In the original algorithm, the intersection does not have the corresponding weights. In this algorithm, each node has its own weight, the value of the weight is the length of the related region. For example, the intersection belonging to the region 5, its weight is 1, the intersection belonging to the region of 1, its weight is 1/8. According to this algorithm, not only the accuracy of the vanishing point is improved, but also the speed is not changed. After determining the area of the vanishing point, progressive scan image [15]. The votes on each column of the Hough space are summed for detecting possible vanishing line.

$$R = \sum_{m=-1}^{-1} \sum_{k=1}^{N} \frac{r_K}{|m|} + \sum_{m=1}^{4} \sum_{k=1}^{N} \frac{r_k}{|m|} + \sum_{k=1}^{N} r_k * 2 \qquad (1)$$

In this formula, m represents the number of rows to be computed for each row of horizontal lines, N represents the number of intersections in each row, and r_k represents the weight of each intersection. The row with the maximum support is chosen as the horizon (or vanishing line) in the image plane as shown in Fig. 6 [16].

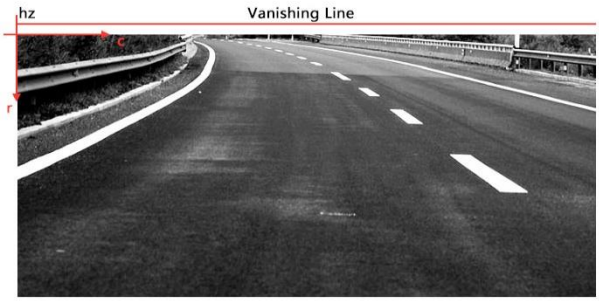


Figure 6. Determination of vanishing line

) According to the vanishing line obtained in step 2, the vanishing point of each region can be calculated. Thus, the two lines of each node are determined. The two intersecting lines are the lanes of the area as shown in Fig. 7.

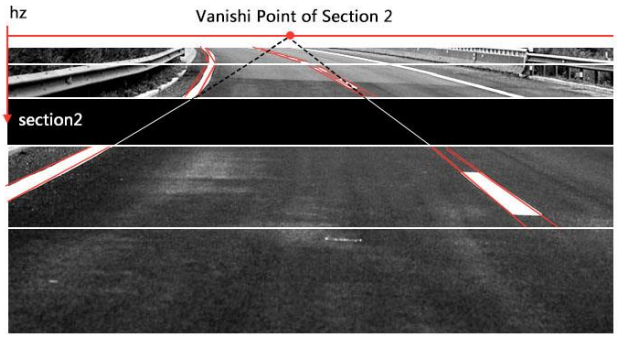


Figure 7. Determine the vanishing point of the region

4) Lane in the above steps are detected by lane edge information, and the internal and external side edge of each lane may be detected as lane, which leads to the instability of the point, so the calculation steps necessary in this lane [17].

According to the sampling area in Fig., the gray level distribution is calculated.

$$c(j) = \sum_{i=1}^{m} L_{m\times n}(i,j), \qquad j \in \{1,2,\cdots,n\} \qquad (2)$$

$$p(j) = \frac{c(j)}{\max(c)}, \qquad j \in (1,2,\cdots,n\} \qquad (3)$$

p(j) is considered as gray level distribution of cross section of lane. The typical cross section of the lane line shows a single peak characteristic [18]. The midpoint of each row selected peak area as the lane line trip point, the line scan, can get the midpoint coordinates of each line. Then the Hof transform is used to detect the longest straight line formed by the midpoint, and the straight line is used as the final line detected by the gray level distribution as shown in Fig. 8.

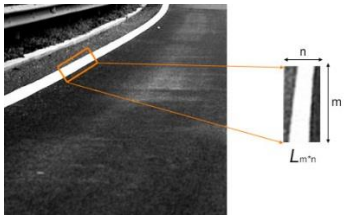


Figure 8. rectangular region $L_{m\times n}$

5) In order to realize the lane line detection of straight line and curve, the B spline curve is used to fit the lane line. B spline curve is easy to realize arbitrary shape curve fitting, as well as smooth, continuous and other advantages, to achieve accurate lane expression. The bottom end of the real lane in the lowest end of the image is selected as the first control point, and then the two ends of the lane line in the closest region below the vanishing line are selected as the other two control points. According to the three control points, the least squares method is used to reconstruct the lane line based on the Cubic B-Spline Curve.

C. *Continuous Frame Error Improvement*

In lane detection, lane line contains less information and regular, once fitting lane line deviation, resulting in greater visual impact. In addition, even if the lane of each frame image in the fitting can be roughly correct, but each lane fitting position must have slightly deviation, resulting in the continuous video, Lane will continuously swing, greatly affect the visual effects[19]. So by voting principle, the output of a certain location of the lane line, rather than the output of each frame detected results. On this basis, do not fit all the frames, but only for the key frame fitting. Thus saving recognition speed. Specific steps as shown in Fig.9 as follows.

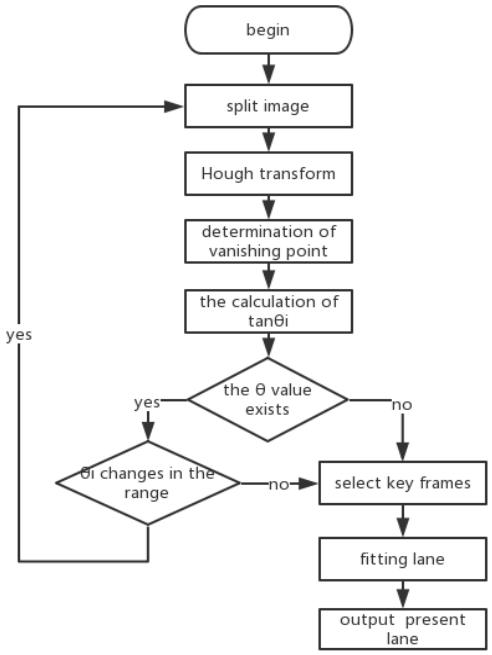


Figure 9. Lane detection process

First of all, the image segmentation, Hough transform processing, get the vanishing line, and determine the vanishing point of each region. The lower end of the lower end region is set as P, and the upper end point of the upper end region is set as P, and the two points are connected to determine the linear equation.

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

According to the basic equation of the θ_i can get the current lane. The whole lane criterion θ exists, that is to say, whether the current is identified as a key frame. If there is, is to determine the current lane and the key frames of θ difference is too large, if too large, to determine the key frame. On the principle of Tan is not the difference between the 0.1 results. If not, keep the current key frame. Key frames are determined by the principle of voting, five lane on the current frame is calculated by θ_1, θ_2, θ_3, θ_4, θ_5. Take the average value of θ selection from the average value of the last frame as key frame, the lane line fitting of key frames, output lane. Then repeat the steps above for each frame. This method ensures that the lane line in the absence of major changes, the output of the same frame to keep the lane line, to ensure that the user's visual effects.

IV. Experimental Results

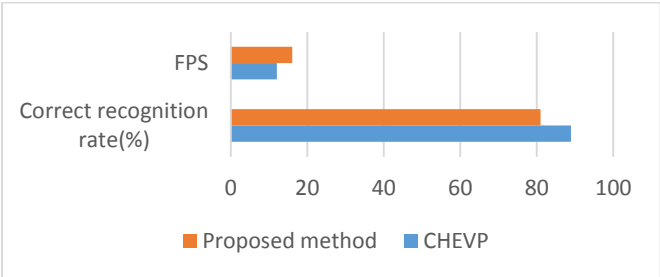
In this paper, the algorithm is based on the VC ++6.0 environment and Open CV image processing library, Image size for processing is 960×836. In this experiment, using iPhone 6 sensor to collect data in free motion, and doing the experiment in the indoor environment.

In order to prove the practicability and efficiency of the method in this paper, we will compare the recognition rate and speed of the algorithm and the CHEVP algorithm. In this paper, 100 Lane images are used as samples. These pictures are taken under different light and different angles. Meet the experimental requirements in different situations. The following data are the average of the sample. From the Table I, The speed of the algorithm is 21ms faster than the CHEVP algorithm. Because the dynamic ROI method is adopted in this paper, the accuracy of the recognition region has been significantly improved [20]. In the missing rate of detection, the difference between the two algorithms is not very large, when the view angle is too low or too high, the recognition rate is better than the original algorithm. Because this algorithm makes a judgment on the illumination, different processing methods are adopted with the images under different illumination conditions. Therefore, in the face of the complex situation of the road, the algorithm has a better recognition rate. From the Table II, the FPS ((Frames Per Second) of the algorithm is a little lower than the CHEVP algorithm, but the correct recognition is better.

TABLE I. Comparison of Two Algorithms

	Algorithm in this paper	***CHEVP algorithm***
Number of samples	100	100
Speed of recognition	62Ms	83Ms
Incorrect rate of detection	15%	8%
Missing rate of detection	4%	3%
Correct rate of detection	81%	89%

TABLE II. Data Contrast with the Different Algorithms



Compared with the different road conditions, the images with different visual angles have better processing ability. The Fig.10 (a) (b) shows that the effect of the algorithm on the lane recognition at different sections of the same road. The Fig.10 (c) (d) shows that the effect of the algorithm on the curve lane recognition at different sections of the same road. As can be seen from the graph, the algorithm has a better recognition effect on different lanes with different visual angles with faster speed.

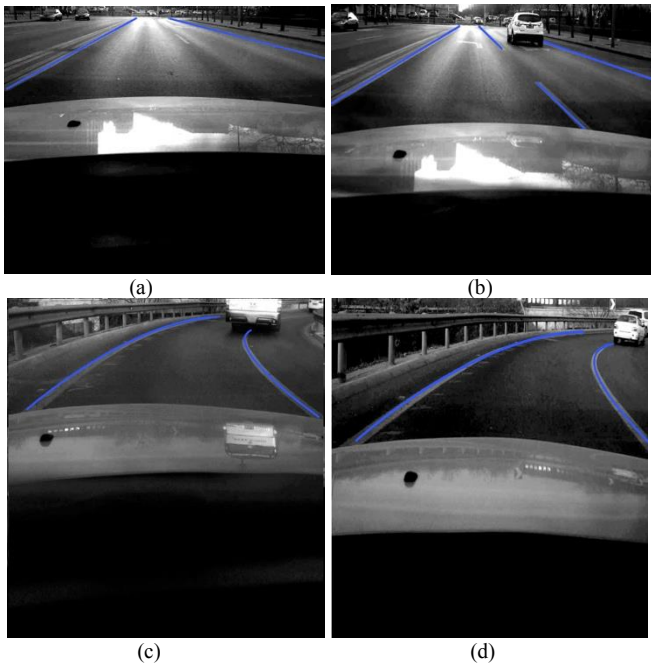


Figure 10. Tracking results with different lane conditions

V. CONCLUSION

This article aims to achieve a higher recognition rate, make the identification results more accurate of lane identification algorithm. In this algorithm, judge the illumination level of the image by calculating the average grey value, classify images according to different light intensity, respectively classified as light images and weak illumination image, in order to use different treatment to different types of images [21]. The dynamic ROI method is used to define the range of the image to be recognized, the amount of calculation is reduced, and the accuracy of calculation is improved. In the recognition process, firstly find the straight part of the lane line using HOUGH transform, then find the vanishing point of each part. To determine the initial segment of each region, and then determine the key frames, each frame of the comparison with the key frame, when the accumulated error exceeds a threshold, select key frames to fit the final output lane.

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