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A Review on ROI Extraction of Lane Detection Based on Machine Vision

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Abstract **– Improving the selection quality of the region of interest is an effective way to improve the real-time and accuracy of lane detection. This paper introduces the common methods of Region Of Interest (ROI), including four methods of Region extraction based on fixed proportion, fixed Region, vanishing point and gray mean of row, and analyzes the implementation methods. The comparison shows that, The four methods listed have obvious differences in adaptability to different environmental disturbance factors, and the application scenarios of different ROI extraction methods are given for reference by relevant scholars. Finally, the research of ROI extraction method is prospected.**

Keywords **– Lane Line Detection, Machine Vision, ROI Extraction, Image Processing.**

I. Preface

From January to May of 2022, China's cumulative vehicle sales totaled 9.555 million units. The driving environment became increasingly complex and traffic accidents occurred frequently [1]. Advanced Driver Assistance Systems (ADAS) has been widely applied, with functions such as lane keeping, signal identification, vehicle distance keeping and automatic cruise, which greatly reduces the driving pressure of drivers and avoids many traffic safety problems. The realization of ADAS function is based on vehicle environment information acquisition system and information processing system. In the realization of these functions, lane line detection and target detection algorithm is the basis of ADAS technology. In practical applications, in order to ensure a certain real-time and reliability, limited by the computing capacity of the onboard processor, it is necessary to minimize the amount of computation and storage space occupied by image information solution on the premise of ensuring the detection accuracy. In the process of image information processing, lane line information (the region where it is located) only accounts for a small part of the image information. In the case of unprocessed image, the global retrieval of the pixel where the lane line is located will drown the lane information, resulting in a large amount of calculation and unable to guarantee the real-time and accuracy of detection. Therefore, reducing the amount of image information and extracting effective areas are of great significance for improving the speed of image processing and the real-time performance of road detection [2]. In the lane line detection, the image is divided into contains a large amount of irrelevant information interference region and the lane line area ROI, interference region contains the background interference information such as the sky, trees and buildings, the background of ROI is commonly with pavement large gradient lane line, and no significant difference, the background information of interference has nothing to do so you need to reduce area, enlarge the ROI accounted for. The extraction of ROI can significantly reduce the amount of information in image processing and improve the real-time performance and robustness of lane detection. ROI region selection can be divided into dynamic extraction and static extraction. This paper makes a comparative analysis of four methods: fixed proportion extraction, fixed region extraction, gray mean extraction and vanishing point extraction. The evaluation index is ROL / ROI (Region of Lane / ROI area). The images in this paper are derived from Cityscapes data set and self-

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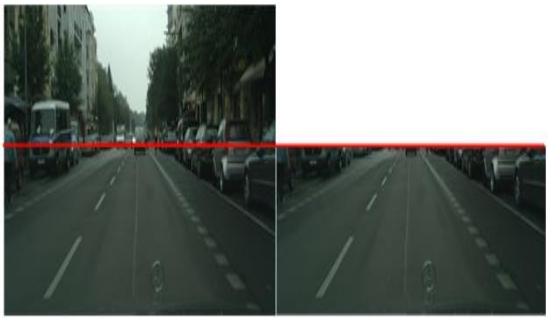
built image set.

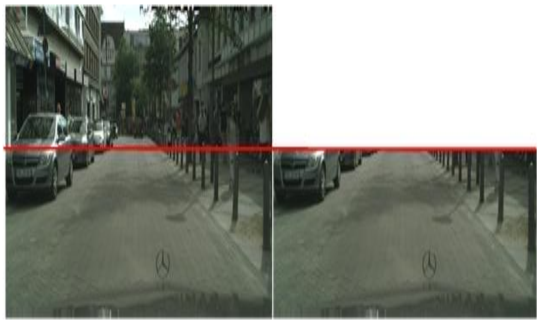
II. Static ROI Area Extraction

2.1. *Fixed Proportion Selection*

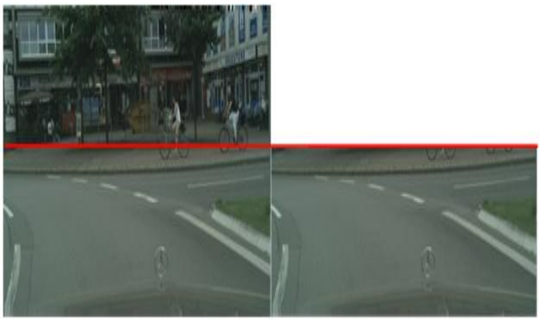
This method directly intercepts part of the image in proportion as ROI, processes the image with a fixed proportion, and analyzes the image. Lane lines exist in the lower part of the image. Therefore, lane line area of the image intercepted with a fixed proportion as ROI has higher ROL/ROI, and the algorithm is simple and the number of parameters is small. It is suitable for long, straight and good road surface with small slope, as shown in Figure 1-a. Since there is no need to process the information of image gray scale, edge, Angle and so on, it has good robustness to clutter information, lane bending and other disturbances, as shown in Figure 1-b and 1-c. This method is sensitive to lane slope. When the vehicle is on the ramp, part of lane line area is cut off, as shown in Figure 1-d, which has adverse effects on subsequent lane line extraction.



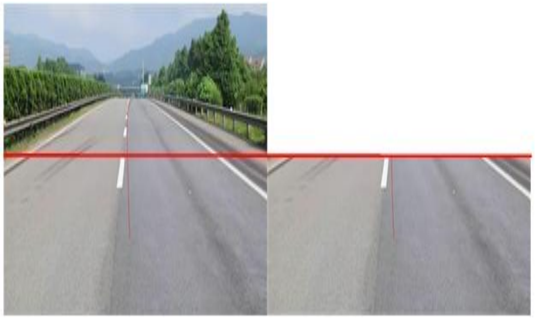
(a) Straight and good carriageway.



(b) Clutter background interference.



(c) Lane curvature interference.



(d) Road slope interference.

Fig. 1. Fixed-ratio ROI extraction.

2.2. *Fixed Region Select ROI Region*

This method pays attention to the driving lane where the vehicle is. During the driving process, there are lane lines on both sides of the vehicle body’s forward direction, so the ROI region is the trapezoidal region in front of the vehicle's driving direction. The included Angle between lane line direction and driving direction was calculated for the data set. The included Angle between lane line and driving direction was -70º~-30º and 30º~70º [3]. Therefore, the point at the lower left corner of the image was taken as the coordinate origin, vertical upward was the positive direction of *X* axis, and horizontal right was the positive direction of *Y* axis. The regions of -70º~-30º and 30º~70º between the straight line angle and the image coordinate system are fixed ROI regions, as shown in Figure 2. Under ideal driving conditions, this method can maintain large ROL/ROI and

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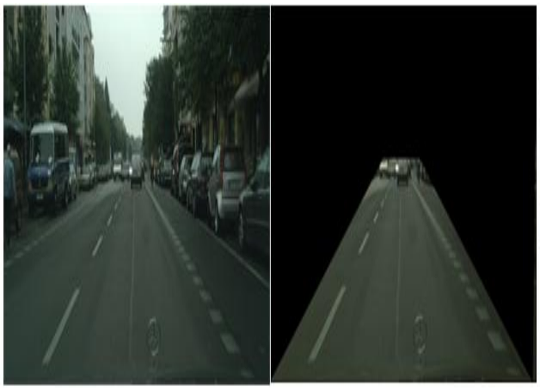
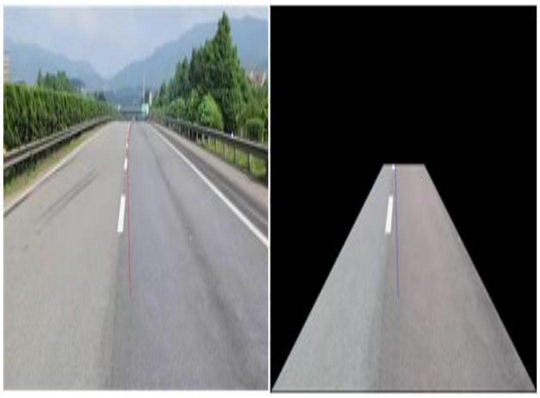
effectively remove the influence of environmental interference such as illumination and occlusion, but it is sensitive to road curvature and other factors, as shown in Figure 2-c. This method can extract the current driving lane, but it cannot retrieve the global information.



(a) Smooth and good road surface.

(b) Lane curvature interference.



(c) Road slope interference.

Fig. 2. ROI extraction of fixed area.

III. DYNAMIC ROI REGION SELECTION

3.1. *ROI Region Selection Based on Vanishing Points*

Without considering the errors caused by camera installation, manufacturing and other factors, the spatial line in the image coordinate system is still a straight line, and a group of parallel lines will intersect at a point under the perspective of the camera, which is the vanishing pint, and the line where the vanishing point is is the vanishing line [4], The literature further[5] extracts the ROI area by detecting the straight line and determining the vanishing point.

Suppose *n* lines that exist in the image, as shown in Figure 3, l_1, l_2, l_3 for parallel lanes, namely three parallel straight line, according to the existence of the vanishing point, l_1, l_2 to the intersection point, into the formula (1) to calculate two lane line intersection point ordinate *y*, according to the linear expression abscissa solving calculation, get the intersection point *p* is the vanishing point, Since l_3 is parallel to l_1 and l_2, l_1, l_2 and l_3 intersect at the same point, the theoretical vanishing point. Theoretically, each set of parallel lines has only one intersection point. However, due to errors in camera imaging, manufacturing, installation and image preprocessing, there are $n(n-1)/2$ intersection points in *n* straight lines in space, and the fitting center of the intersection point is taken as the blanking point. Let the equation of line i be $y_i = k_i x + b$, and the calculation is shown in Equation (2).

$$y = \frac{k_i \cdot b_i - k_j \cdot b_j}{2} (i \leq n) \tag{1}$$

$$\begin{cases} \bar{x} = \frac{2}{n(n-1)} \sum_{i=1}^{\frac{n(n-1)}{2}} x_i \\ \bar{y} = \frac{2}{n(n-1)} \sum_{i=1}^{\frac{n(n-1)}{2}} y_i \end{cases} \tag{2}$$

Fig. 3. Schematic diagram of linear relation and vanishing point.

The line length threshold filtering in the line detection process should meet the purpose of removing the pixel where the short line segment resides. The direction threshold filtering should filter the straight direction after the line length threshold detection, and the pixel where the lane line resides should be retained [7]. By adjusting the experiment, the threshold value of the straight line length is set to 1000 pixels (The real length is 1.0*m*). The direction threshold filtering process establishes the image coordinate system, with the point at the lower left corner of the image as the coordinate origin, vertical upward as the positive axial direction, horizontal right as the positive axial direction. The Angle between the straight line angle and the image coordinate system is -70º~-30º and 30º~70º. As shown in Figure 4, the line is detected after threshold filtering, and the disordered and short line segments are filtered out. Put them into Formula (1) to solve the intersection point of the line and fit the vanishing point. Figure 5 is the effect diagram of ROI extraction based on vanishing point.

Line detection is performed on the image and line length and direction are filtered to obtain line parameter information in the image [6]. Figure 3 is the flow chart of line detection:

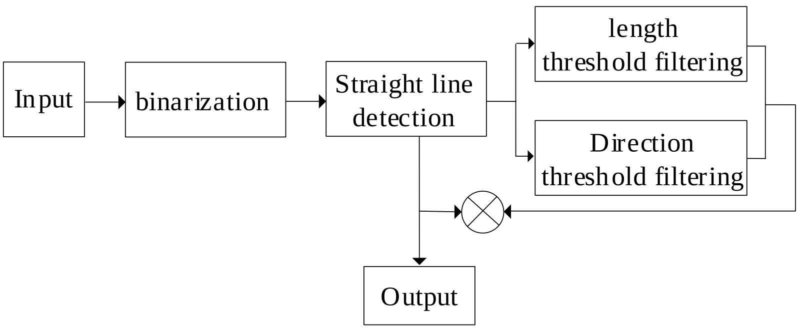


Fig. 3. Flow chart of linear detection.

Fig. 4. Linear detection and vanishing point fitting.

Fig. 5. ROI extraction of fixed area

This method has good robustness when the lane is flat or has small curvature. In the environment with strong environmental interference, chaotic background or poor lighting, the vanishing point may be misdetected or drift, which leads to the failure of ROI extraction. As shown in Figure 6, there is no obvious straight line detection in the detection. Short straight lines are detected after the detection threshold of straight line length is reduced, and the calculated vanishing point drift cannot be used to extract ROI normally.

Fig. 6. Vanishing point drift caused by environmental disturbance.

3.2. *ROI Region Selection Based on Average Gray Value*

After the sensor is installed in the vehicle, the range of video information collection is fixed. Assume that the resolution of image frame collected by the sensor is $m{\bullet}n$, m and n are the number of image frame rows and columns respectively. Therefore, the lower boundary of ROI region m1 is the m line of image frame, and the upper boundary of ROI region row m_2 needs to be solved. The following is the ROI extraction method based on average gray value.

I. *Image Grayscale Processing*

Converting an image to grayscale image reduces the amount of image data and facilitates subsequent processing. The commonly used grayscale processing includes maximum method, component method, average method and weighted average method [8].

II. *Maximum Method*

The maximum RGB component of the sensor image is taken as the gray value of this pixel.

$$gray(i,j) = \max\{R(i,j), G(i,j)\, B(i,j)\} \tag{3}$$

III. *Component Method*

This method is aimed at different lane color problems and grayscale processing is carried out with specific color channels.

$$gray(i,j) = \begin{cases} R(i,j) \\ G(i,j) \\ B(i,j) \end{cases} \tag{4}$$

IV. *Mean Value Method*

The method takes the average value of RGB channel of each pixel of the image obtained by sensor as the gray value of the pixel.

$$gray(i,j) = \frac{\{R(i,j), G(i,j)\, B(i,j)\}}{3} \tag{5}$$

V. *Weighted Average Method*

In this method, different RGB color channels are weighted with different weights as the gray value of the pixel. Since the human eye has different sensitivity to different colors, ω_R, ω_G, ω_B, values of 0.299, 0.587 and 0.114 respectively can achieve better grayscale effect.

$$g(i,j) = \{\omega_R R(i,j) + \omega_G G(i,j) + \omega_B B(i,j)\} \tag{6}$$

Figure 7 shows the comparison of four different gray-scale methods. method (1) A highlighted area is formed in the red circle of the sky background, and the original gray-scale information of the image is lost, and the lane information has no obvious distinguishing effect. method (2) In the case of yellow lane, there was obvious loss in the process, and the lane line position produced shadows which damaged the integrity of the lane line, as shown in Figure 8 in the red circle; method (3) The image after processing is relatively smooth, which reduces the contrast between lane lines and road surface, and adversely affects the subsequent extraction process; method (4) The lane line and ground background were distinguished well, and the contrast between sky and ground was improved, which was conducive to the extraction of ROI. By contrast, the weighted average method is selected as the average gray value method of image processing.

Method (1)

Method (2)

Method (3) Method (4)

Fig. 7. Effect comparison of different gray-scale methods.

Fig. 8. Shadow of lane line area.

VI. *Solve the Gray Mean*

After graying the image, the mean value of gray-scale G_i is solved line by line.

$$G_i = \sum_{j=1}^{n} \frac{g_{ij}}{n} (i = 1, 2, ...m, j = 1, 2, ,...n) \tag{7}$$

In the formula, G_i is the gray mean of row i, and g_{ij} is pixel gray value of row i and column j.

The camera sensor collect the image analysis, image and road border area have obvious distinction in the sky: the sky area has a relatively large grey value and change is relatively small, gray value is opposite bigger, the ground area where two area transition has great gray level change, can be used as a characteristic of the average grey value solution. Figure 9 is the solution flow chart.

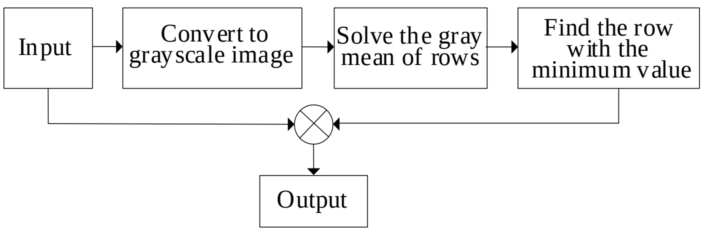


Fig. 9. Solving flow chart of gray mean method.

The image was grayed, and the gray mean of rows was solved and the minimum of the global gray mean was found, as shown in FIG. 10. There were obvious gray changes in the area where the sky and background intersected with the lane, so the row with the minimum global gray mean (the row where the red line is) was selected as the upper boundary of ROI. The ROI region is the image row, which has good robustness to road factor interference, as shown in Figure 11. However, this method is sensitive to gray scale changes. Under the condition of mixed background information and sky blocked by trees and buildings, gray scale changes cannot be used as a judgment condition for ROI region selection, resulting in false detection. As shown in Figure 12, the sky in the figure is blocked by trees and buildings, and the minimum line of gray mean cannot be used as a selection mark.

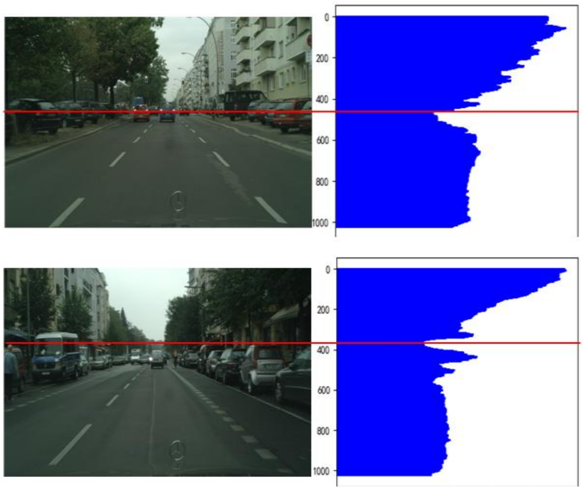


Fig. 10. ROI extraction based on gray mean.

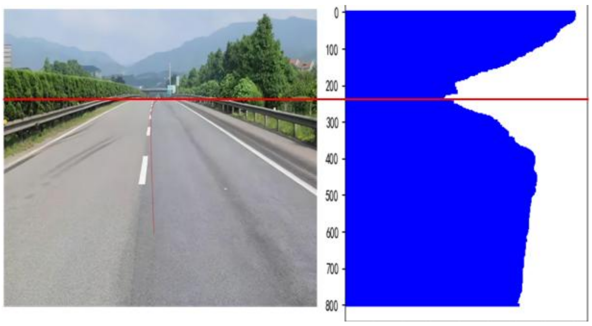


Fig. 11. Road disturbance factors.

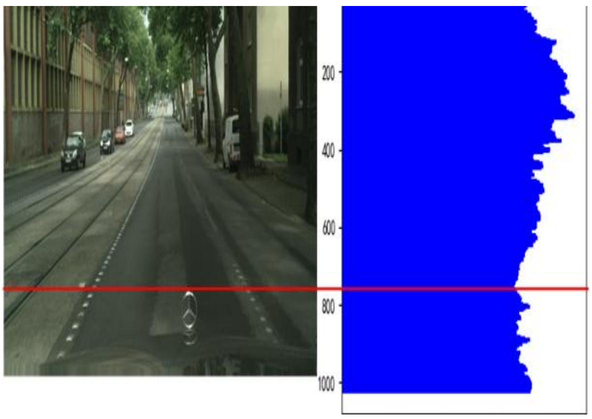


Fig. 12. Clutter of environmental factors.

IV. Summary and Prospect

The full text is summarized, and the existing ROI area selection methods are prospected. The selection of ROI area in lane line detection is of great importance to improve the real-time and accurate determination of ADAS system. In ROI selection, improving ROL/ROI can effectively improve the real-time performance of subsequent processing processes and reduce the demand for on-board computing power. For the four selection methods involved in this paper, they have different performances under different environmental factors. The static method to extract ROI is based on fixed proportions and regions, and the influencing factors are mainly concentrated on road factors. The images are not processed, and only rely on fixed regions or proportions. so it has better robustness to ambient light and background factors and achieves a higher ROL/ROI value, but it has high requirements on the driving road, and factors such as road curvature and slope have a great influence on the fixing method; the dynamic selection method can adapt to different road surfaces. However, the technical realization is based on the calculation of image information, which is sensitive to factors such as light background. The image straight line is detected based on the vanishing point method and the average gray value method, and the disappearance in the image can be determined under the environment of sloped road or curved road However, in an environment with poor lighting, the detection rate of straight lines is low, resulting in vanishing point drift. At this time, the vanishing point cannot be used as a reference for ROI selection. In practical engineering, because the vehicle is inevitably driven in the environment of bad lighting, lane interference, background clutter and occlusion, the combination of two or more selection methods can effectively avoid the interference of environmental factors. Therefore, the ROI extraction method should have strong robustness. The image information is processed in different ways under different lighting, background and other environmental factors. Therefore, designing a joint ROI area selection method with strong adaptability is an inevitable requirement to improve the real-time and accuracy of lane line detection.

Table 1. Comparison of different ROI extraction methods.

ROI Selection Scheme	Mark Parameters	Influence Factors /● Sensitivity				ROL/ROI
		Light	Curvature	Slope	Background	
Based on fixed ratio	Fixed ratio		●	●		●●
Based on fixed area	Fixed area		●	●		●●●●●
Based on vanishing point	Image line detection	●		●	●	●●●
Based on row gray value	Gray mean solution	●			●	●●

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