Research on Lane Detection and Tracking Algorithm Based on Improved Hough Transform

Xianwen Wei[1]
Department of Electronic Information Engineering
Wuwei Occupational College
Wuwei, Gansu Province, China
e-mail: wwocwxw@163.com

Zhaojin Zhang[1]
Department of Electronic Information Engineering
Wuwei Occupational College
Wuwei, Gansu Province, China
e-mail: zhangzhj@lzu.edu.cn

Zongjun Chai[2]
School of New Energy and Power Engineering
Lanzhou Jiaotong University
Lanzhou, Gansu Province, China
e-mail:157752086@qq.com

Wei Feng[3]
Highway College
Chang'an University
Xi'an, Shaanxi Province, China
e-mail: fengwei0701@163.com

***Abstract*—The driverless technology has developed rapidly in recent years. Unmanned vehicles need to learn to observe the road from the visual point of view if they want to achieve automatic driving, which specifically is the detection of lane lines. This includes identifying the positional relationship between the lane line and the car, whether it is a solid line or a dotted line. The detection of lanes is an important part of the vehicle-aided driving system. In view of this feature, this paper proposes the use of improved Hough transform to achieve straight-track detection of lane detection, while for the detection of curved sections, the tracking algorithm is studied. By controlling the slope of the lane lines in the two frames before and after comparison, a limitation is made near the previously detected lane line area, ie, a region of interest (ROI) is set, and a search for a corner pixel is performed in the direction, for the corner portion Rebuild. The experimental results show that the algorithm has the characteristics of fast operation speed, high accuracy and good robustness.**

Keywords-driverless; lane detection; hough transform; region of interest

I. INTRODUCTION

The driverless system is a hot topic in the past two years. Due to the development of society, the improvement of economy, the continuous improvement of urban traffic, the number of cars has increased year by year, and various types of traffic safety accidents caused by automobiles have also increased. Today, with the continuous development of technology, the driverless system is constantly updated and improved [1]. The driverless system is a complex intelligent control system that integrates multiple modules such as mechanical control, path planning, and intelligent sensing, and finally uses the in-vehicle computer system to realize automatic driving operations. The purpose of the development of the driverless system is to provide better safety and comfort for car driving, develop smart transportation in the city, and solve a series of problems such as urban traffic congestion. Therefore, the research of unmanned driving has great practical significance and the future prospect is very broad.

The sensing module is an important module in the driverless system. It mainly senses the driving environment during the driving process of the vehicle, and senses vehicles, pedestrians, obstacles and other objects in the surrounding environment of the vehicle, and provides the result of the sensing and the path decision module. The corresponding path planning is carried out, and finally the mechanical control module realizes the relevant mechanical control operation, so that the car can drive automatically. Lane line detection is an important part of the sensing module. Unmanned driving not only requires obstacle avoidance and road traffic information perception, but also needs to comply with traffic rules. The requirements for lane line detection are relatively high. Many traffic rules are designed so that pedestrians and vehicles must move according to certain rules. In addition to the traffic signal, the reference standard is the road lane line. By detecting the lane line, the ground indicator can be further detected and the front collision warning strategy can be designed.

II. LANE DETECTION

The lane line is a traffic sign that stipulates the basic driving specifications of the car. Lane line detection plays an important role in both traditional assisted driving and current unmanned driving. The driverless system uses lane line detection to provide early warning of vehicle deviation, and warns when the vehicle is about to collide with the preceding vehicle. At the same time, lane detection can provide the most basic operations for automatic cruise driving, lane keeping, and vehicle overtaking. The importance of information to protect the normal running of vehicles is self-evident and the research is far-reaching.

In an unmanned system, lane detection is an important part of ensuring that the vehicle is driving correctly. The lane line detection algorithm involves the correct driving of the vehicle, which is related to the safety of the occupants in the vehicle and the safety of the vehicle itself. The lane line

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detection algorithm must be able to identify and handle all kinds of traffic markings and correctly analyze the lane position, but due to the complexity in the real world, so the task of lane detection is still very challenging.

There are many methods for detecting lane lines. Vision-based lane line detection includes detection based on Hough transform principle, LSD line detection, lane line detection based on top view transformation, and lane line detection based on fitting. Aly [2] proposed a real-time and robust method to detect lane markings on urban roads. Using the simplified Hough transform, the filtered results were detected in a straight line. The original lines were used to locate lane lines. The algorithm did not Use tracking. Zhou et al [3] used the model matching method to detect the two main lanes in front of the vehicle and determine its position and curvature. Inverse perspective transformation can eliminate the perspective effect in the traffic image, and it will have near-big and small features. The driving front view is converted into a top view effect. The converted matrix can generally be obtained by camera internal reference and external parameter calibration calculations. Generally, it is effective for relatively flat roads because the lane lines in the diagram are parallel after the reverse perspective transformation of the driving picture. If the road has a certain slope, the lane line will have a certain intersection after the reverse perspective transformation, which is disadvantageous for the latter to find the pixel line of the same lane line. Therefore, this method is effective only for flat roads and has certain limitations. In addition, Alon et al. [4] proposed a method of combining geometric projection with Adaboost algorithm to find a travelable area, which requires a large number of different road areas as a training set to train the road area classifier. Liu Fuqiang et al [5] proposed a lane line detection algorithm based on the three-dimensional road model, based on the lane line color mutation, detecting the boundary of the lane line, and using Kalman filter to achieve the lane line tracking. The method is robust and can achieve high quality detection results when there are many vehicles with complicated road conditions. However, due to the complexity of the algorithm, the algorithm is time consuming.

III. EXPERIMENT

Most roads on the road are basically straight, and there are few sharp bends in the curve. Therefore, in the lane detection and tracking, the Hough transform is used to detect the line and determine the approximate position and shape of the lane. Then determine the deviation direction of the lane by the slope of the lane, and then find the curve part of the lane. In this way, the accuracy of the detection of the lane line can be ensured, and there is no serious error in the detected curve.

A. *Image Preprocessing*

The preprocessing of the image is mainly to pre-process the image captured by the camera in real time, mainly including removing various noises of the image, performing edge detection, etc., in order to enhance the useful information of the image and suppress interference [6].

For the original vehicle image, it is the color image of BGR. For the algorithm that only needs to extract the lane line, the lane line is white, we only need to keep the thickness map of the white lane line, so the first step of the original map processing It is grayscale. The empirical formula for the transformation is as follows: This formula is based on the proportion of three different photoreceptor cells in the human eye.

$$Y = 0.299 \times R + 0.587 \times G + 0.114 \times B$$

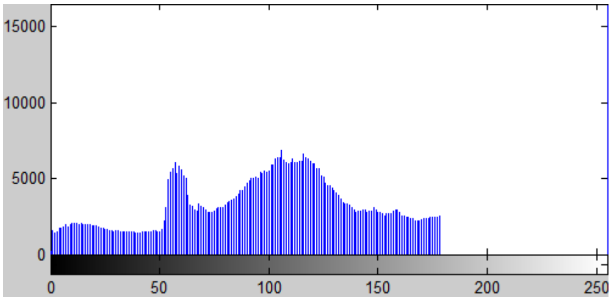
At the same time, it should be noted that from RGB to grayscale images, a mapping function is essentially established. For a well-established mapping function, we can always find that the points obtained after mapping different points in RGB space are basically the same. The reason is also very simple, from 3 channels to 1 channel must be accompanied by the loss of information. The solution is not fixed mapping function, according to the picture to do a dynamic mapping function.

First step gray balance:

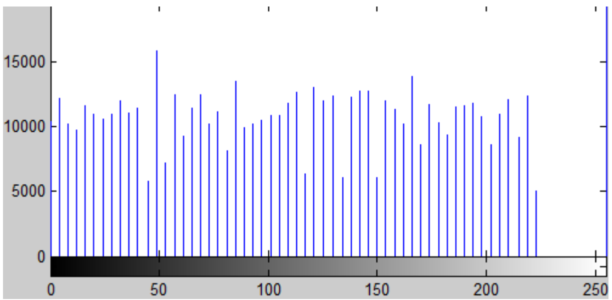
Figure 1 Straight-track inspection.

Figure 2 Grayscale.

Figure 3 Histogram equalization.



(a) Original histogram



(b) Equalized histogram

Figure 4 Equalization.

The second step is edge detection:

There are many methods for edge detection, such as sobel operator or canny edge detection [7]. The difference is that the weights in the detection operator's template are different, resulting in differences in the details of the last retained edge.

Figure 5 3*3 template median filtering.

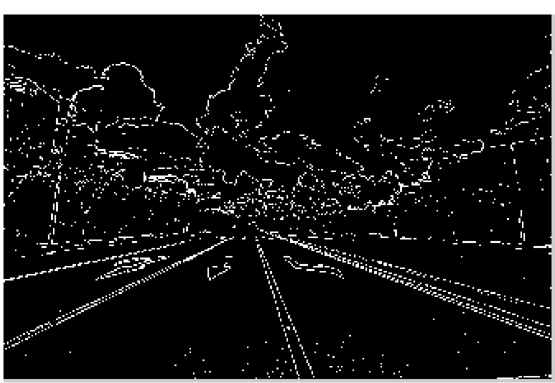


Figure 6 Image processed by sl, sr operator.

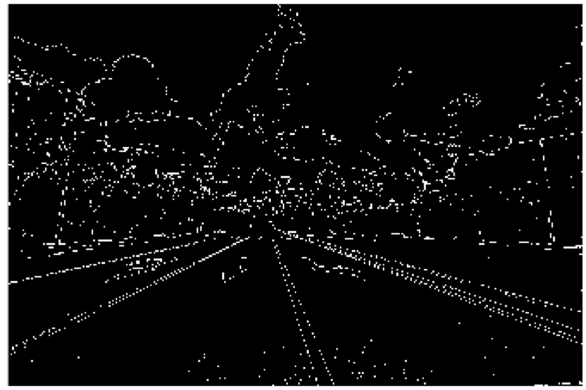


Figure 7 Refined image.

B. *Extraction Lane Line*

The Hough transform is a feature extraction technique [8] that detects objects with a specific shape, usually straight lines, circles, and ellipses. The principle is to imply the original space into the parameter space and vote in the parameter space to obtain the desired graph. The lane line detection in this paper is based on the statistical introduction Hough line detection. The principle is the transformation from points to curve, in which the important step is to convert the Cartesian coordinate system of the image to the polar coordinate Hough space. And the result is the transformation from each pixel coordinate $P(x, y)$ in points to (ρ, θ) above the curve points.

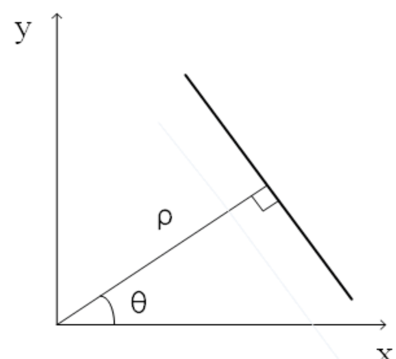


Figure 8. The principle of Hough transformation.

Point $P(x, y)$ on the same line is satisfied: $x * \cos\theta + y * \sin\theta = \rho$, Such a set of (ρ, θ) constants corresponds to a straight line determined by the displacement in the image. When traversing the pixels of the image region of interest, the number of data points corresponding to each (ρ, θ) is continuously accumulated. When the number of points corresponding to a pair of (ρ, θ) reaches the threshold we set, the points are considered to be in a straight line. By the number of points on the same line detected by Hough, many interference lines can be filtered out.

Find the straight line through Hough and find the lane line:

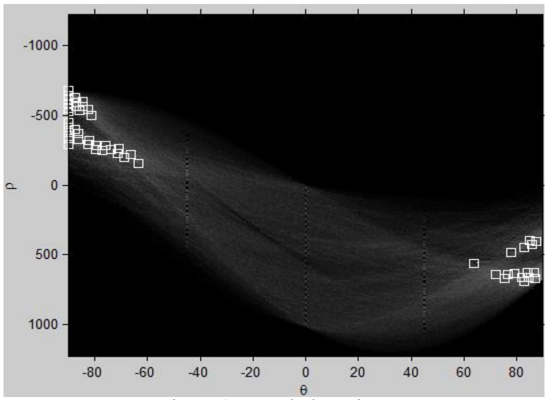


Figure 9. Hough detection.

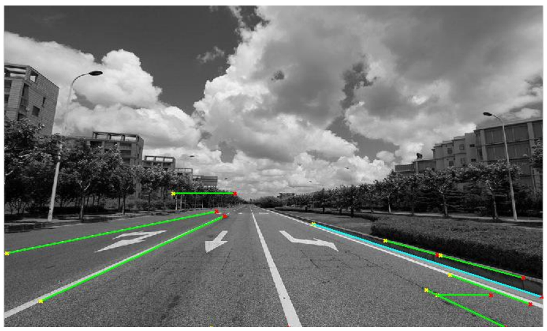


Figure 10. Lane detection results.

C. Lane Line Detection Based on Hough Transform Improved by ROI Region

Because the lane line is easy to be lost during detection, in order to ensure the accuracy of the detection effect, this article uses tracking technology to improve the detection speed and accuracy. The basic idea of the tracking is that the vehicle is a continuous displacement movement process during the advancement of the vehicle. The change of the lane line is also a continuous change. This change is reflected in the slope of the lane line. The slope of the lane line in the two frames of the front and rear images are not much different from the position of the lane line. Therefore, the two frames before and after the control are compared. The slope of the lane line in the middle is limited near the previously detected lane line area. This is the basic idea of tracking. Finding lane lines within the area of interest can greatly reduce the amount of image processing

For the situation that the lane lines of the road in the image are generally distributed on the left and right sides of the road, the application of the traditional Hough transform is improved in this paper to limit the scope of its voting space, that is, to define ρ and θ to adjust the scope of its voting space. The polar angle and the polar diameter of the left and right lane lines are limited, and the camera is adjusted. Through continuous testing, the polar angle constraint area and the polar diameter constraint area of the target point are obtained, and the region of interest (ROI) is obtained, and only lanes in the white area are detected.

By establishing the polar angle and the polar diameter constraint area, a large number of interference points can be effectively removed, the interference of the roadside tree buildings can be filtered out, and the running speed of the algorithm can be greatly improved. When the polar angle of the lane line is within the detection area, the position of the lane line can be quickly and accurately detected. However, when the image is shifted in a turn, lane change or camera position, the lane line easily exceeds the detection area, so that the results appear some deviations.

For the traditional Hough transform, each point needs to be traversed at each angle, which is time consuming. In this paper, the modified Hough transform is used to perform Hough transformation on the vanishing point and the limited pixels around it. The two peak points of the left and right lane lines are obtained and the lane lines are drawn. This method can effectively suppress other edge noises of the image and improve the real-time performance of the algorithm.

Tracking is divided into vanishing point tracking and lane line tracking. (1) Vanishing point tracking: vanishing points are generally far away, and the vanishing point range of vehicles is not changed very much during the progress of the vehicle. On both sides of the road near the lane line, the contact of the vehicle tires is frequent and the texture is more obvious. The contribution to the vanishing point is Larger. Therefore, randomly select 100 pairs of points near the vanishing point line and several points around it (this paper selects 36 points) to vote. (2) Lane line tracking: According to the results of the previous frame measurement, the limited angle is within a certain range of variation (this article is limited to a range of 10°, Hough transform is performed, which greatly reduces the operation speed. When the number of vanishing points and lane lines of the image detection is less than the upper point of the set threshold, the program is reinitialized.


Figure 11. Curve detection original

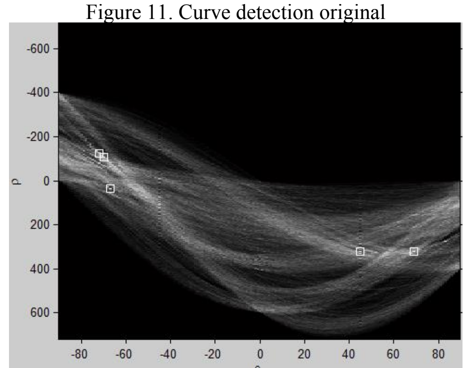


Figure 12. Curve Hough detection.

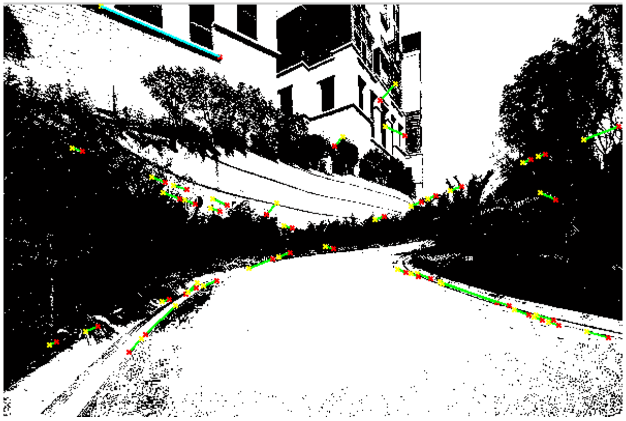


Figure 13. Curve test results.

IV. CONCLUSION AND FEATURE WORK

The Hough line detection method is accurate and simple, and the curve detection can be performed after adding the tracking algorithm. The fitting method [9] is unstable and has the advantage of being able to detect curves. The advantage of the affine transformation [10] method is that multi-lane detection can be performed. The disadvantage is that in a complex situation, the vehicle or other object in front can be easily obstructed and suffer severe interference. Therefore, the detection of lane lines needs to adapt to various conditions. Compared with the above two algorithms, the algorithms designed in this paper have good robustness and obviously have many advantages.

This algorithm is not only applicable to structured roads with lanes such as roads, but also can be applied to non-structured roads such as country roads with clear traces of road rugs and asphalt roads without lane lines, and can more accurately detect the vanishing point of roads. When the direction of travel of the vehicle deviates from its vanishing point, the driver is reminded to take corresponding measures so as to realize the lane departure warning, which can effectively suppress the occurrence of the accident.

The algorithm designed in this paper cannot completely avoid the interference of other lines in the identification. Further research is needed for the selection of the region of interest. For the detection of curves, we can also try to improve the recognition efficiency of the curve by combining the fitting method. Make the entire lane detection system more precise and complete.

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