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Design and Implementation of Lane Line Detection Algorithm Based on Image Recognition

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Abstract: *With the progress of science and technology, intelligent automation equipment is gradually applied to the production and life of the entire society. Significant progress has been made in the research of intelligent vehicles, the development and application of automatic recognition and lane recognition. In the future, with the increasing demand for recognition accuracy and speed, research in the field of track line recognition will become increasingly popular. There are many algorithms for detecting track lines, but when comparing the advantages and disadvantages of different algorithms, some problems were found, such as poor robustness of track line detection, and poor real-time track line detection due to the influence of other signal lines. Based on the original classic algorithm, this article expands the scope of use, improves the speed of trajectory detection and recognition, and improves the speed without affecting the effectiveness of trajectory detection. At present, fuzzy and multi-modal detection problems are the biggest problems encountered by classical Hugh transform and are strongly influenced by noise. This article will improve the Hugh transform to enhance the robustness and adaptability of the detection results.*

Keywords: *Image recognition, Canny Operator, Grayscale Processing, Sober Algorithm*

1. Introduction

Lane recognition is an important branch of image processing and traffic intelligence, especially in recent years. With the development and application of automobiles and automatic recognition, research on lane recognition has made significant progress. In the future, as people's requirements for recognition accuracy and speed increase, research in the field of lane recognition will become increasingly popular. It can be said that this is an emerging research field.

The research achievements in lane recognition [1] largely benefit from the development of digital image processing and computer technology. With the rapid development of computer technology, artificial intelligence, and ideological science research, digital image processing has reached a higher and deeper level. People are beginning to study how to use computer systems to interpret images and obtain an understanding of the external world similar to the human visual system, which is called image understanding or computer vision. Many countries, especially developed countries, have invested more human and material resources in this field and achieved many important research results. The representative result is the visual Theory of computation proposed by Mal at MIT in the late 1970s, which has become the dominant idea in the field of computer vision for more than ten years. Although significant progress has been made in understanding images in both theoretical and methodological research. But this itself is a relatively difficult research field, with many difficulties. Due to a limited understanding of human visual processes, computer vision is a new field that requires further exploration.

In the 1960s and 1970s, the development of autonomous navigation for smart cars attracted the attention of researchers from around the world. In the 1980s, the development of autonomous navigation for smart cars reached a climax. The enormous employment prospects and military value have been appreciated by Western countries, and many countries have invested a large number of human resources and scientific and technological research resources. The detection and recognition technology of lane markings is an important component of visual navigation systems and is considered one of the important research topics in various countries. The Traffic sign line is the sign of the road traffic system. For the detection technology of the lane line, the recognition of the Traffic sign line is the key to realizing the lane line deviation alarm system and the basis to ensure the orderly driving of vehicles. In the research and development of this technology, there have been many breakthrough achievements in various

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countries around the world, including representative technology research such as the RALPH system developed by Carnegie Mellon University [2] (CMU) in the United States, the Mobile-ye AWS system in the 3Netherlands, and the RDT system developed by the German National Defense University. However, the research on intelligent vehicles in China started relatively late but has now reached a leading position. China's autonomous driving technology has been continuously catching up with the world's leading level and has achieved good results in related fields. Based on the current development progress, we believe that in the future, China will reach an international leading level in the field of intelligent vehicles.

2. Difficulties and shortcomings

The development of the Internet of Things will undoubtedly bring breakthroughs and innovations in the development of intelligent vehicles. We look forward to smart cars entering the homes of ordinary people as soon as possible, bringing comfort, safety, and comfort to our lives. Real-time efficiency and springiness are the goals of lane inspection. After experimental simulation and implementation, due to the large number of system modules, there are still some problems in the overall system during experimental testing, which are manifested in the following aspects:

(1) The Canny operator [3] has the best edge detection performance, but for some images with particularly dim lighting or road surfaces covered with cover, the Canny operator can only detect very few edges, which still poses great difficulties for real-time monitoring of road information. In the future detection process, other edge detection operators can be considered to be combined.

(2) The straight curve detection method based on the Hugh transform in the article has a good effect on straight line detection, but there are certain problems in curve detection under changing environments. Further improvement and optimization are needed to further improve robustness and anti-interference ability, and meet the requirements of actual vehicle experiments.

(3) Most existing lane detection algorithms mainly focus on structured road structures rather than structured roads. They are influenced by the surrounding environment such as trees or building shadows, as well as the influence of vehicles ahead of the road on the lane line, thereby reducing the correlation of lane line detection.

(4) Due to the influence of other symbols on the stripes, or when the stripes are damaged or severely polluted, the collected stripe images by the system are incomplete and of poor quality, making it difficult to accurately judge and analyze the data, and even less able to ensure real-time detection of stripe lines.

3. Project innovation points

The algorithm in this project has better improvements compared to traditional algorithms:

(1) The problem of fuzzy detection and multi-modal detection is the biggest problem encountered by traditional Hugh transform, and it is strongly interfered with by noise. Once the Hugh transform is improved, the strength and adaptability of the test results will be improved.

(2) To overcome the problems of weather change and unclean camera lens, this paper uses a two-dimensional Median filter to process the original image. In the edge detection stage, the Kirsch algorithm has obvious advantages. This article is based on the original classic algorithm, which has increased the image processing speed by more than twice compared to the original algorithm, expanded the scope of use, improved trajectory detection and recognition speed, and improved the speed without affecting the trajectory detection effect.

(3) Compared to traditional recognition algorithms, the algorithm in this project has been optimized to improve the accuracy of recognition.

(4) The algorithm has undergone certain improvements, greatly reduced computational complexity, and improved computational speed.

4. Lane line image acquisition

During the Lynn detection process, the images processed by the system are recorded by the camera. To simulate the image information collected from the camera while driving a car, Lynn's image lines are

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taken from Lynn's actual image lines.

4.1 Image per-processing

Thanks to real-world road conditions and other external communication, the smartphone camera captures images of content such as light points and pixels. The degradation of image quality directly affects the detection and recognition of target information lane lines.

Image processing is therefore a necessary step before analyzing and evaluating image information. The main purpose of image per-processing is to reduce interaction with unnecessary information, but it can also improve targeted information, reduce the integrity of post-processing algorithms, and effectively improve arrest procedures.

4.2 Grayscale processing

As shown in Fig. 1, the image obtained by the camera is a color image, which contains a large amount of unnecessary interference information compared to the track line information we need to analyze and detect. Due to the small amount of information contained in grayscale [4] images, trajectory detection algorithms [5], it is usually directly processed in grayscale image processing, which is faster for subsequent detection algorithms.

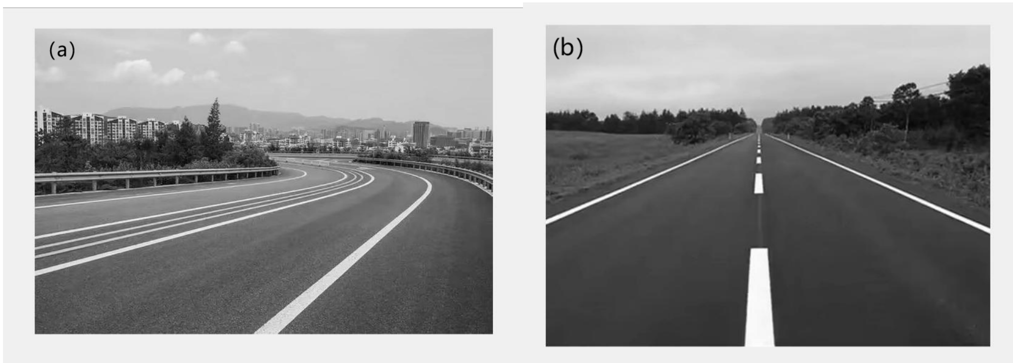

Figure 1: Grayscale image

4.3 Filter processing

The most common noise source in the collected lane line image is Salt-and-pepper noise. The characteristics of the noise are relatively obvious, usually black and white pulse points. Salt-and-pepper noise filtering is mainly to highlight the target information and reduce the complexity of later algorithm processing. There are three common filtering methods, namely median filtering, mean filtering, and Gaussian filtering. Next, we will discuss these three filtering methods' principles and processing effects.

Image edge enhancement is the process of magnifying the differences between different features of an image, effectively emphasizing the overall and local characteristics, highlighting the information in the region of interest, and suppressing the influence of non-regions of interest.

Four common image enhancement methods exist histogram equalization, image smoothing, image sharpening, and pseudo-color methods. Histogram refers to the distribution of brightness and darkness in an image, and equalization is the process of homogenizing an image with extremely uneven distribution to improve its quality; Image smoothing and image sharpening mainly focus on the contour details of the image, making it soft and clear; The pseudo color method refers to the use of color to replace the grayish white in an image, converting the grayish white part into a color image, to better represent the grayscale changes in the image. Comparative experiments on four methods found that the histogram equalization method has the best processing effect. This article focuses on introducing this method.

5. Research on Image Edge Detection Algorithms

The so-called image edge refers to the area where the gray value changes sharply in the image. Because the color of the lane line image and the road background are quite different, at this time, the area

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with sharp gray change can be found through the gray distribution gradient of the image, and this area can be extracted, which is the lane line information to be detected. Before edge detection [6], the image is usually barbarized to remove irrelevant information.

The Sober algorithm [7] is relatively simple in implementation, as it can provide accurate edge information and has good noise resistance performance. However, the disadvantage of this operator is that it may generate edge pseudo information, mainly caused by local averaging, resulting in low accuracy in edge localization. So, when the accuracy requirement is not high, this operator can be used.

$$Edge\_Gradient(G) = \sqrt{G_x^2 + G_y^2} \tag{1}$$

$$Angle(\theta) = \arctan\left(\frac{G_y}{Gx}\right) \tag{2}$$

$$f^{(-1)}(x) = \lim_{h \to 0} \frac{f(x+h) - f(x-h)}{2h} \tag{3}$$

Robert Edge calculation is a 2x2 template that uses the difference between two adjacent pixels in the opposite direction. From the actual effect of image processing, the edge localization is accurate and sensitive to noise. Suitable for image segmentation with clear edges and low noise. Robert's edge detection algorithm is a method that uses local difference algorithms to find edges. However, after processing the image, the edges of the field are not very smooth. Analysis has found that since the Robert algorithm typically provides a wider response near the edge of the image, the above algorithm detection usually needs to be adjusted, and the edge positioning accuracy is not very high.

$$G[i,j] = |f[i,j] - f[i+1,j+1]| + |f[i+1,j] - f[i,j+1]| \tag{4}$$

The Canny algorithm is a multi-stage optimization algorithm that integrates filtering, enhancement, and detection. Before processing, the Canny algorithm uses a smoothing filter to smooth the image and remove noise. The Canny segmentation algorithm uses the finite difference of the first order Partial derivative [8] to calculate the gradient amplitude and direction. Canny's algorithm is also subjected to the process of extreme suppression. Finally, Canny also used two thresholds to connect.

Finally, by comparing the results of several sets of detection maps, we found that the Canny detection operator has obvious advantages, extracting the most abundant information and achieving the best detection effect.

6. Lane line road model and recognition (though, curve judgment)

6.1 Line Curve Recognition Based on the Hugh Transform

Hugh transform is one of the basic methods to recognize the geometric shape in the image in image processing [9]. The basic principle of the Hugh transform is to use the duality of points and lines to transform the given curve in the original image space into a point in the parameter space through curve expression so that the problem of checking the given curve in the original image becomes the problem of finding the peak in the parameter space, that is, the inspection of the entire feature is converted into the inspection of local features, For example, lines, ellipses, circles, arcs, etc.

Different road models have obvious advantages and disadvantages. Linear models have simple descriptions and low operational complexity, but environmental factors are significant. It is assumed that the vehicle speed is slow or the line of sight is clear enough to meet the inspection and testing requirements; The curve model can adapt to road conditions with complex environments and large curvature, but with high computational complexity, which cannot meet the real-time requirements of the system.

Therefore, this section proposes a method that combines the recognition of straight lines and curves, which can efficiently identify lane lines under different road conditions. The algorithm steps are as follows:

(1) Extract lane line information and perform Hugh transform for line detection

(2) Determine if a curve model is needed

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(3) Fit the spline according to the situation and display the detection results

6.2 Extension of the Hugh Transform

(1) Known radius circle

The Hoff transform can detect curves in the form of any known expression, and the key is to select its parameter space [10], which can be defined based on its expression form. For example, the expression for a circle is as follows: when a circle with a certain radius is detected, a space similar to the original image space can be selected as the parameter space. Therefore, a circle in the circular image space corresponds to a point in the parameter space, a point in the parameter space corresponds to a circle in the image space, and points on the same circle in the circular image space have the same parameters, namely A and B. Therefore, the corresponding circle in the parameter space passes through the same point (A, B). Therefore, after converting all points in the original image space into parameter space, based on the degree of aggregation of each point in the parameter space, it can be determined whether there is a shape similar to a circle in the image space. If there is, then this parameter is a parameter of a circle.

(2) Unknown circle radius

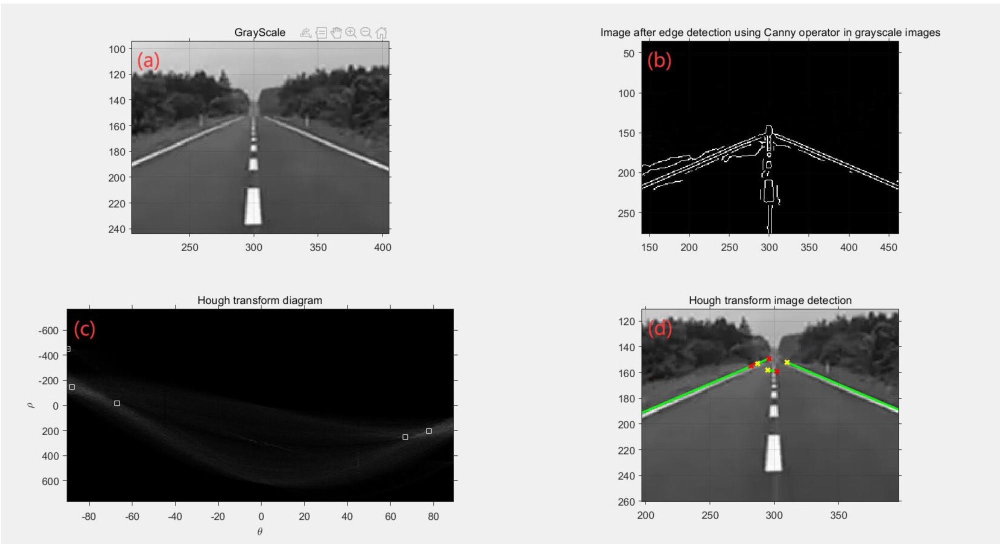
When the radius of a circle is unknown, it can be considered as the detection of a circle with three parameters: center and radius. At present, this principle remains unchanged except for the increase in dimensional and computational complexity of the parameter space. Each point in the image space corresponds to a cluster of circular curves in the parameter space. It is a cone. Each point in the parameter space corresponds to a circle in the image space.

(3) Ellipse

Ellipse has 5 free parameters, so its parameter space is 5-dimensional, so its computational complexity is very large, so many improved algorithms have been proposed.

The experiment is divided into grayscale images and images detected by Canny operator edge detection, as well as experiments on images detected by Hugh transform and Hugh transform. A 1659×904 standard lane line optical image was selected for grayscale detection, in which Fig.2 (a).is from https://m.163.com/dy/article/C8OKDL5T05289TAQ.html?spss=adap_pc&from=wapShare

The standard grayscale image was successfully obtained. Next, the edge image is obtained through Canny operator edge detection. The figure shows that after using Canny edge detection in Fig.2 (b), the edges can already be effectively recognized. The phenomenon of recognizing strong noise as edges has a low error rate; Then, after undergoing the Hugh transform, the final result was obtained, as shown in Fig.2 (d), which performed a relatively complete recognition of the lane lines in the original image.



(a)Grayscale (b)Image after edge detection using the Canny operator in grayscale images
(c)Hough transform diagram (d)Hough transform image detection

Figure 2: Image of the result

7. Conclusion

In this article, Lynn reveals these images through image implementation. After detecting vehicles and boundaries, an alarm function was set up. The channel detection algorithm in this article performs the following tasks: Road images and equipment, mainly used for gray image, contrast, and edge extraction. Detection through improved Lynn half conversion. Create a left-right forest mixed Gaussian model. Weather forecasting and tracking progress. The experimental results show that the proposed algorithm is effective. Expected test results will be obtained. Of course, some problems have also been found in practical applications, mainly including the adaptability of the algorithm is not high enough for complex road conditions and poor weather conditions; For some interference factors that exist in reality, such as road edges, they cannot be effectively eliminated. These existing problems also point out the direction and ideas for improvement in the next stage, and there is still more work to be done in the future. In the future, with the continuous development of artificial intelligence, machine learning, and other technologies, applying these technologies to lane recognition will greatly improve the accuracy and adaptability of lane recognition. With the further development of intelligent vehicles, new technologies will continue to be applied, and lane recognition technology will usher in a major development. Especially domestically, with the continuous improvement of China's technological level, the market needs to continue to increase, and the demand for automatic recognition of lane markings will also become more urgent. So, the future is bright, but we need to be down-to-earth and constantly make breakthroughs.

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