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System Design of Lane Deviation Alarm and Lane Maintenance

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Abstract: In today's rapid economic development. Cars have become an indispensable part of our daily life. But with the increasing number of cars, the incidence of traffic accidents is getting higher and higher. Traffic safety has become a social problem that cannot be ignored by governments of all countries. Therefore, the application of safe driving assistance system appears, and the lane departure warning and lane keeping system is one of the important research directions. This paper studies and designs a lane departure warning system that can accurately identify lane lines, which mainly includes three parts: lane detection, lane identification and software program design. Among them, the detection of the lane line uses image processing methods such as filtering, enhancement, smooth denoising, graying and binarization, and Canny operator edge detection to obtain the target image with lane line features. In the lane line recognition section, the method of ROI segmentation, least squares, etc. are adopted to realize the recognition of straight lanes and curved lanes. The software program design part uses the code of Camera 2 API and algorithm to write, and finally realizes the basic function of lane departure warning and lane keeping system.
Keywords: Lane departure alarm, Lane identification, Region of interest

I. INTRODUCTION

With the rapid development of economy, the car has become a necessary means of transportation for almost every family. However, although cars bring great convenience to people's travel and life, the personal injury and economic loss caused by traffic accidents every year also bring people deep introspection. According to statistics, a total of 8.643 million traffic accidents occurred in China in 2016, including 212,846 traffic accidents involving casualties, causing 226,430 injuries and 63,093 deaths, with direct property losses reaching 1.21 billion yuan. In most of these accidents, drivers are tired or distracted. The only effective way to solve this problem is to make cars smarter.

In recent years, various countries and enterprises have invested a lot of money and scientific research efforts to develop intelligent vehicles, which has become an inevitable trend of the development of the automobile industry. Lane departure alarm system, as an intelligent vehicle auxiliary system, greatly improves the active safety of vehicles, not only reduces the incidence of traffic accidents, but also reduces driver fatigue, which has very important research significance.

There are two common lane departure alarm systems, vehicle-based and road-based, to judge lane departure, and then to alarm the driver through sound alarm or dashboard display, so as to avoid traffic accidents caused by lane departure.

(1) vehicle-based lane departure alarm system

The system is mainly used to determine the position of vehicles through machine vision. Due to the different locations of camera installation, the system is divided into two types: forward view system and overlooking system.

The feature of the vehicle-based forward view system is that it can make use of all kinds of information in the lane image and work normally even in the sections with poor lane identification lines. However, too much road information may interfere with the signal extraction process, thus affecting the normal extraction results of lane lines.

The advantage of the vehicle-based overlooking system is that it can locate the lateral position of vehicles more accurately, especially on the structured roads. But there is great uncertainty about how well the system will work on poorly marked roads.

(2) lane deviation alarm system based on road structure

This lane departure warning system has special requirements on the road structure. Currently, a popular way of road design is to place special objects below the lane line to mark the lane line (such as electrical wires). During the driving process, the car receives the mark signal under the lane line through the sensor to locate the position of the car in the lane. This method has certain anti-interference ability to all kinds of disturbance and noise on the road surface, but the manpower and material resources needed to complete the road reconstruction are too large, so it is not very circulating in reality.

Lane departure warning system is part of the intelligent vehicle safety assistance system, which aims to reduce the probability of traffic accidents caused by driver's unconscious deviation. This paper studies and analyzes the lane departure alarm and lane maintenance system based on monocular vision, compares the existing design methods of lane departure alarm system at home and abroad, compares and analyzes various image processing algorithms, selects the efficient algorithm, and improves it on the existing basis. Finally, a lane departure alarm system with high accuracy and real time is proposed.

II. LANE LINE DETECTION ALGORITHM DESIGN

Lane line detection is an essential step of lane deviation alarm system. The accuracy and real-time performance of the alarm system will directly depend on whether the lane line image information can be detected quickly and accurately. In the process of road image acquisition, due to image conversion, the content of the image will produce certain noise information, including light and shade, uneven road surface and obstacle occlusion, etc. Because of these factors, the collected road image will contain a lot of noise. In order to detect the correct lane line information, it is necessary to carry out some pre-processing operations on the road image.

A. Lane line image information collection

In this paper, the CMOS camera installed on the working platform in front of the vehicle is used to take photos of the road in front of the vehicle. The road information captured from the image video is read frame by frame, and the lane line image is preprocessed, detected and recognized according to this image information. CMOS camera is a highly integrated low cost image sensor, and the images taken are very programming friendly and adaptive.

B. Lane line image smoothing and denoising

In the road image collection, noise will be generated in the road image due to the interference factors of the environment on the road or the internal factors of the equipment, which will bring great efficiency loss to the subsequent processing of lane line images and greatly affect the image processing results. Generally, the method of filtering automobile road image is firstly used to reduce the noise interference in the road image. In this paper, the method of mean filtering is proposed to smooth and de-noising the road image. Mean filtering is a linear filtering algorithm, which means to divide an area on an image, select a pixel in this area, calculate the average value of the covered part in this area and assign the value to the target pixel. Assume the coordinate of the center pixel is (x,y). According to the part contained in the region, take the values of several surrounding pixel points and calculate the average value, as shown in figure 1.

Figure 1 Mean filter

C. Graying and binarization of lane line images

The image taken by the camera is a color image, which contains not only the brightness information of the image, but also the color information of the image. The color image can be divided into R, G and B components, and the variation range of each part is between 0 and 255. There are 256 ways to select each color [9]. The RGB value can be converted to YCbCr color space, because the human visual system is not very sensitive to color, and the most visually meaningful information in color images is reserved in the y-component of grayscale information of images. Thus, the lane detection program calculates only the Y components, while the chrominance components (CB and Cr) are discarded because the human visual system is insensitive to them, and it has the advantage of saving data storage and reducing computation time.

Grayscale image is measured by light and dark information. The number of each pixel represents the brightness or darkness of the object, which does not contain color information. The value range of grayscale is between 0 and 255, so only 256 possibilities can be considered after image grayscale, which greatly reduces the calculation amount and time consumption of image algorithm.

Image binarization is a method to process images through the change amplitude of gray scale. Assume a certain threshold value of gray scale T, and use the threshold value T to divide the gray image into two parts according to the pixel value of each pixel point. The part larger than T is the foreground target and the part smaller than T is the background [10]. Therefore, the selection of threshold T is particularly important for binarization. If the value of threshold T is low, shadows on the road and buildings on both sides of the road will be identified as part of the lane line, which will greatly reduce the detection efficiency of road edges. However, if the threshold T value is high, part of the lane line edge will be considered as the background part, and the characteristics of the corresponding lane line will be reduced.

III. THE DESIGN OF LANE LINE IDENTIFICATION ALGORITHM

A. Division of areas of interest

The lane departure alarm system based on monocular vision needs to process the image information mainly through the CMOS camera installed in front of the car. In the process of image acquisition, due to the perspective, most of the areas in the image do not need to be processed. That is to say, there is always information unrelated to lane lines in the collected images, such as separation belts on both sides of the road, obstacles, interference of digital signs on the lane, and distant buildings in front of the road. In order to reduce unnecessary workload in image processing, regions of interest (ROI) are often used in image processing.

According to the analysis of road image, the upper part of the road image is set as the perspective area, two-thirds of the lower part of the image is set as the sub-close-up area, and the lower part of the image is set as the close-up area.

B. Lane line identification in close-up area

Since only a small part of the image information in the lane image is selected in the close-up area, and the lane line information in this area is the most effective and important, and the range of lane line variation is the smallest, both the straight line and the curve lane line model in the close-up area can be regarded as a straight line approximately. Therefore, in the lower half of the sub-close-up region, the line equation detected in the close-up region is used to draw the line.

In Hough transform, the target image after the early stage of the pretreatment, namely smoothing denoising, gray, filtering, binarization and so on, these actions will improve the identification of the edge of the lane line, through the Hough transform to detect the straight line, to a single line of two boundaries can be detected, it is not easy to deviate from the judgment in the late. For the above problems, the Hough transform is improved as follows.

Through the analysis of a large number of image data, certain restrictions can be imposed on the slope of the straight line, so as to filter out some unnecessary non-lane line. According to the definition of image coordinate system in Matlab, the top left vertex of the target image is selected as the origin, the horizontal right is the y axis, and the vertical downward is the x axis (this method is to ensure that all pixel points in the target pixel can be positive), as shown in figure 2.

Figure 2 Target image coordinate division

C. Lane line identification in sub-close-up area

In the actual driving process of vehicles, curves are likely to be encountered, and curves are mainly concentrated in the sub-close-range region of interest. Therefore, in the analysis of sub-close-range region of interest, this paper will identify the feature points at the edge of the curve marking line, and then take these feature points as the basis for curve fitting. In this paper, the edge feature points of all identified lane lines will be used as the curve fitting of the sub-close-up area. The method of curve fitting is the least square method.

First, the Hough transform is used for linear detection in the close-range region and sub-close-range region respectively. Then, according to the detected linear equation, it is determined whether curve fitting should be carried out, and then the corresponding fitting points are selected. Finally, the fitting points are fitted. In this paper, the fitting points of the straight lines in the two regions are selected. In the actual fitting process, both the straight line and the curvilinear lane can be approximately regarded as a straight line in the close-range area. Therefore, in the lower half of the lane line image, the line equation detected in the close-range area is used to draw the line, while most of the images in the sub-close-range area are fitted by the least square method according to the selected fitting points, as shown in figure 3.

Figure 3 Curve Lane Line Fitting

IV. CONCLUSION

Lane deviation alarm and lane maintenance system is a very important part of intelligent driving assistance system and the foundation of driverless vehicle. Through the analysis of real-time highway information images collected by cameras, the system realizes the detection and recognition of lane identification lines, and determines whether the vehicle has unconsciously deviated from the lane through the results of image recognition and vehicle driving parameters, and finally gives the driver feedback results. Through the analysis of different image processing algorithms, this paper obtains the design ideas of the system, and extracts the algorithm

applicable to the system and the improved algorithm, and finally realizes the basic functions of lane deviation alarm and lane maintenance system.

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