Research on Lane Recognition of Auto-Driving Vehicles

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Abstract. This paper introduces the algorithm design of lane recognition system. In the binarization module, a double-division maximum inter-class variance filter iterative algorithm is proposed to guarantee the speed and quality of binarization. In the middle, the close-up part adopts the block-type Hough line extraction technology, and the second close-range part adopts an approximation-based extraction method to ensure the processing speed.

1. Introduction
The primary problem of vehicle autopilot system navigation and positioning, this paper uses visual positioning is the collection and processing of vehicle position and surrounding driving environment information. Since the vehicle mostly travels along the lane line on the road, the lane line can also serve as the basis for the direction of the road extension. Therefore, the lane line is the main identification target. In this paper, the vehicle autopilot system adopts visual navigation technology to collect road information in front of the vehicle through CCD sensor. In this design module, digital image processing technology is used to perform image preprocessing and recognition.

2. Skeletonization module
The skeleton is intended to represent the connection topology or shape of the target shape. Image skeletonization refers to simplifying an original multi-pixel combined image into a single-pixel connected binary image. The biggest advantage of image skeletonization is that it can perform data compression without losing the edge or topological information of the image. This method is widely used in pattern recognition, machine vision and CAD. In this paper, the method of skeletonization is applied to the lane recognition system to remove a large number of unnecessary pixels without losing the original lane extension information of the image. The data amount of the binary image is greatly reduced, and the subsequent processing speed can be improved.

The skeletonization algorithm has been matured to a great extent after the efforts of the predecessors, and will not be described in detail in this article. Table 1 compares the number of pixel lines in the lane line before and after the skeletonization of the near-field image. It can be seen that after the skeletonization algorithm processing, the number of data points of the binary image is greatly reduced, which is of great significance for the subsequent image recognition, and the processing speed of the recognition algorithm can be greatly improved.

| Table 1. Data volume comparison table before and after binary image skeletonization |
|---------------------------------|-----------------|-----------------|
|                                | Amount of data before processing | After processing | Data reduction |
| Data                           | 4479             | 1076            | 75.97%         |
3. Lane line identification module

The purpose of the lane recognition system is to identify the lane line and determine the vehicle's control strategy based on the lane line and the positional relationship of the vehicle. Through the previous binarization and skeletonization processing, the lane line in the image becomes a thin line connected by a single pixel. First, the lane line thin line in the image is extracted, and then the extracted thin line is mapped into the mathematical coordinate system by a fitting method for guiding the vehicle control. This is the main purpose of this section.

In the image processed in this paper, the near-field portion is the closest to the vehicle and the image is taken closest to the actual situation, so the lane line in this part is regarded as a straight line. This part of the lane line extraction method selects the classic Hough transform. However, there is a case in which this method must be considered: when there is text or digital interference in the close-up image. At this time, since the characters or numbers also contain straight strokes, the Hough transform algorithm is disturbed, and the extraction result is inaccurate.

There may be text or speed-limiting digital interference on the road where the vehicle is traveling. These numbers or words may make the system unable to recognize the lane line or make the identified lane line position inaccurate. The traditional Hough algorithm displays multiple peak points in the parameter coordinates when identifying such images. It is difficult to determine which peak point corresponds to the lane line. In view of this situation, this paper refers to the local two value binarization method mentioned in the previous binarization algorithm, and divides the close-up image into six rectangles, as shown in the close-up image segmentation of Figure 1(a), which ensures each The rectangle contains only numbers, words, or lane lines, as shown in the text box in Figure 1(b) and the lane line in Figure 1(c). When there are numbers or words in the rectangle, a number of inconspicuous peak points appear after Hough transform; a rectangular image with lane lines shows a distinct peak point after Hough transform. For this difference, it can be used as a basis for identifying lane lines.

![Figure 1. Schematic diagram of straight line extraction of close-up image](image1)

In order to ensure that each square contains only numbers or lane line information, this paper selects a rectangle with a size of 50*50, and then performs a Hough transform on each rectangle. In the rectangle after the Hough transform, there is only one rectangle of the peak point, that is, the lane line is included; otherwise, and the rectangle with multiple peak points is filtered out. The result of the Hough transform is shown in Figure 2.

![Figure 2. Hough transform result comparison chart](image2)
In Fig. 2(a), the effect of the entire near-field image after Hough transform shows that there is no particularly obvious peak point, and it is impossible to separate the corresponding lane line; (b) The figure is divided into rectangles and only contains text. Rectangular Hough transform results, which are at least 4 peak points, because the text has different strokes, each small rectangle contains multiple strokes, so multiple peak points are generated in the transformation; (c) the diagram is a rectangular segmentation. After that, only the Hough change result of the small rectangular area of the lane line can be seen, and only one of the peak points can be seen. From this it can be concluded that a small rectangle containing only one Hough change peak point is the area where the lane line is located.

4. Binarization method selection

In the actual road conditions of the vehicle, it is often affected by factors such as light, rain, snow, shadows, etc., so that the road condition information collected by the sensor appears at multiple levels. As the vehicle is constantly moving and the position of the vehicle is constantly changing, these factors will also change, which requires the binarization method we use to adapt to the influencing factors of these constant changes. The local enthalpy binarization method can solve this problem, but because the vehicle runs fast and needs safety considerations, this requires the processing speed of the binarization algorithm to have good real-time performance, stability and reliability. Sex. In this paper, a new binarization method combining adaptive threshold binarization and global threshold binarization is proposed. The traditional maximum inter-class variance method is improved and combined with the traditional mean algorithm to select the threshold value. By different segmentation of the image, different threshold determination methods are adopted in different sub-images to meet real-time stability and stability. Reliability requirements.

According to the actual camera shooting angle and the range of the shooting, as well as the different characteristics of the information contained in the far-reaching and near-field of the captured image, the landscape image is divided into three parts, namely, the distant view, the next close view and the close view. As shown in Figure 3.

![Figure 3. Image segmentation diagram](image-url)

The uppermost portion in Fig. 3 is the distant view portion. In the Vision section, most of the information contained is scene features and road information that has no effect on vehicle travel. So this part of the image information can be ignored, completely set to black. In this way, the object we mainly deal with becomes the second close-up and close-up part.

In Fig. 3, the middle part is the second close-up part, and the second close-up part often contains the key information for pre-judging the driving of the vehicle, and since the distance from the vehicle is far away from the light and other factors, this part is the second part of this paper. The focus and difficulty of the value. The maximum inter-class variance method has good stability and reliability. Its characteristic certificate conforms to the requirements of the algorithm in this paper, but the slow processing rate of this method is the key problem we have to solve. In order to improve the speed and
further improve the reliability, this paper improves the traditional maximum inter-class variance method to suit the strict requirements of the algorithm in the second close-up part. The lowermost portion is a close-up portion, and is further divided into two small sub-images in the near-field portion, labeled a and b. The close-up part is the part closest to the vehicle sensor. It is minimally and most clearly affected by other factors. In the real-time consideration, this paper selects the simplest method of mean binarization. The lane line contained in the close-up section directly guides the vehicle to operate.

In this paper, the image is divided into three parts, and different binarization methods are used to perform binarization in parallel to further improve the processing speed. Finally, the results of the three parts are combined and the results are combined to form the final image that guides the vehicle.

5. Simulation of Vehicle Autopilot System Supported by Virtual Reality Technology

Since virtual reality technology can interact well with the real world, this paper establishes a virtual vehicle driving road environment, including the lane line surface. And in this virtual environment, a car model with two control nodes is built, including speed and direction. The image information captured on the actual road condition is coordinately associated with the road environment in the virtual environment, and the motion of the vehicle model is guided as system input information.

The focus in this process is the correspondence between the lane line coordinates of the virtual road environment and the lane line coordinates on the actual captured image, which is the key to the vehicle model being able to operate in accordance with the input image. Since the vehicle distance and the vehicle speed signal input cannot be simulated during the experiment, the parameters of the two variables are directly set in this paper, but the vehicle speed information after the automatic driving system control can be reflected by the virtual model. This part uses the computer and FPGA development board that installs virtual reality software as the experimental equipment. The computer is used as the observation platform of the virtual reality environment. The FPGA development board of the FPGA program that has been programmed in the autopilot system of this paper is used as the system control platform to simulate. Experiment.

a). Lane line following system virtual reality simulation

In this paper, the actual highway condition is taken as the system input, and the system performs coordinate transformation on this image. Since this coordinate corresponds to the lane line coordinates in the virtual reality system, it can be observed in the virtual reality environment as long as the system control can be accurate. Then the vehicle model can travel according to the virtual lane line. In the simulation experiment, the experiments were carried out in straight and curved roads respectively. Give a simulation screenshot of the straight road driving state, as shown in Figure 4.

![Figure 4. Lane line following function virtual reality simulation diagram](image)

b). Virtual Reality Simulation of Safety Distance and Collision Avoidance System

The virtual reality simulation of this part of the system only needs to add the vehicle distance information (given in the form of parameters), the vehicle speed information (the front speed and the vehicle speed, and also given the parameter form) on the basis of the upper part. The three different situation models established by the vehicle are simulated by given different parameters, and the operation of the system straight vehicle model is observed. This paper gives a simulation screenshot of the vehicle's reaction when the vehicle in front is stationary, as shown in Figure 5.
The final overtaking path is planned in the overtaking system, and then the vehicle will operate according to this path under the control of the intelligent controller. In order to make this process more convenient for observation, this paper makes minor changes to the virtual reality environment during this part of the simulation, so that the automatic overtaking system gives the virtual reality system path parameters after the path planning is completed, and the virtual reality system will be in the virtual environment. Give the path marking line, then observe whether the marking line is reasonable and whether the vehicle can overtake normally, as shown in Figure 6.

Figure 5. Safety distance and collision avoidance function virtual reality simulation diagram

c). Automatic overtaking system virtual reality simulation

Through the virtual reality simulation of each system module, it can be observed that the virtual vehicle model completely follows the input image and the expected operation, which meets the actual needs.

6. Conclusion

This paper uses the virtual reality technology to simulate the automatic driving system of this paper. System function simulation in a virtual reality environment is the best choice due to limited experimental environment. In this paper, the virtual trajectory of various road conditions is used to visually observe the running trajectory and running state of the vehicle. The simulation results are in line with the actual situation.

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