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Lane Line detection and Vehicle Identification Using Monocular Camera Based on MATLAB

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Abstract: *Road detection and vehicle recognition are one of the core technologies of Advanced Driving Assistance System (ADAS). The main research content of this paper is road detection and vehicle recognition under the monocular camera, and select examples to realize simulation and simulation through the computer version (CV) algorithm in MATLAB software. The recognition rate of the algorithm for single/double lanes reaches 95 %, the recognition rate of dashed/solid lines reached 97%, and the recognition rate of vehicles reached 99%. The results show that the lane detection algorithm used in this paper can better complete lane line detection and vehicle recognition, and has higher recognition accuracy and better practical value.*

Keywords: *Monocular camera, computer vision, road detection and vehicle recognition*

1. Introduction

1.1 Background

Computer vision is a science that studies how to make machines "see". Further, it refers to replacing human eyes with camera and computer for machine vision such as target recognition, tracking and measurement, and further doing graphics processing to make computer processing into images more suitable for human eyes to observe or transmitted to instruments for detection [1]. Computer vision can also be regarded as the study of how to make artificial systems "sense" from images or multi-dimensional data. Its ultimate research goal is to enable the computer to be able to observe and understand the world through vision like human beings, and have the ability to adapt to the environment independently. In addition, computer vision gradually shifts from the combination of traditional hand-built features and shallow models such as Histogram of Gradient (HOG) and scale-invariant Feature Transform (SIFT) to the deep learning model represented by Convolutional Neural Network (CNN) [2,3,4]. Table 1 shows the comparison between traditional and deep learning methods.

Table 1: Comparison of traditional method and deep learning method

Method	Feature Extraction	Decision models
Traditional method	SIFT, HOG, Raw Pixel …	SVM, Random Forest, Linear Regression …
Deep learning method	CNN …	CNN …

Road detection is a hot application in the field of computer vision (CV). Through the application of image processing and CV algorithm, lane line detection, obstacle detection, pedestrian detection, vehicle detection and other functions in the road can be realized, which is of great importance to many fields such as urban planning, navigation, traffic command and electronic map [5, 6]. Traditional road detection methods are manual vectorization, vehicle-mounted road detection or hand-held road detection to achieve manual update or semi-automatic update [7]. But as the economy boomed, the length of roads increased rapidly. Using the traditional manual or semi-automatic method to accurately update the road database is far from meeting the practical requirements. Therefore, it is very important to develop and improve the new method to improve the detection efficiency. The rapidly developing computer vision algorithm has increasingly become the research hotspot of road detection.

1.2 Literature Review

In recent decades, researchers around the world have proposed a variety of algorithms to realize the automatic identification of structural and non-structural roads, mainly using road features to adopt

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straight line or curve model fitting. Linear fitting usually adopts Hough transform, but the discrete calculation method of this transform will make the obtained results not one-to-one correspondence with the route, but decompose, scatter, repeat and even contain unrelated line segments. Therefore, the detection results of Hough transform have to be transformed back to the original image space for further screening [8, 9]. This process makes the lane line detection algorithm complicated and the detection results are not accurate. On the other hand, due to the interference of light, shadow, occlusion, road damage and so on, the detection is more difficult [10].

Therefore, based on the existing lane detection methods, this paper proposes a road detection method based on monocular camera, which is realized by MATLAB software, and achieves high lane line and vehicle identification accuracy.

2. Road detection method and test simulation

The framework of visual perception using monocular camera research can be expressed as Figure 1.

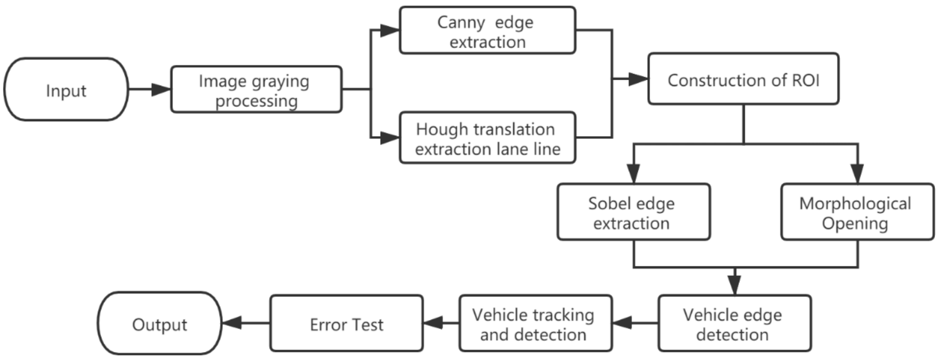

Figure 1: Flow chart of road detection method

2.1 Camera parameter preset and video preprocessing

In road detection, the internal and external parameters of the camera are crucial to the accurate transformation of image coordinate system and vehicle coordinate system. Firstly, the parameters of the camera are defined. The parameters are generated after the checkerboard map calibration of the camera in the previous step, and the "Camera Calibrator" function in MATLAB can be used to calibrate the camera. If the distortion is small, the distortion parameter can be omitted.

Next, the camera direction relative to the vehicle chassis is defined, namely the camera external parameters. The camera external parameters define the position of the 3D camera coordinate system relative to the vehicle coordinate system. As shown in Figure 2 below, the X axis points to the front of the vehicle, the Y axis points to the left side of the vehicle, and the Z axis points above the ground.

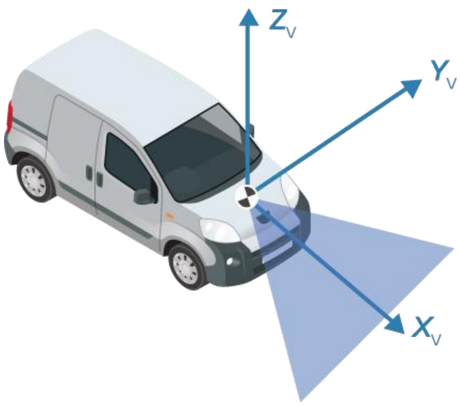

Figure 2: Vehicle coordinate system

By default, the origin of the coordinate system is on the ground below the center of the camera as defined by the camera focus. The origin can be moved by using the sensory-positioning property of a

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single lens object. It should be noted that the coordinate transformation assumes that the road is a flat road, which is calculated based on the homography mapping matrix from the image plane to the road surface. An uneven road surface can affect the distance of detected objects, especially objects that are far from the vehicle.

Then a "VideoReader" object was created in MATLAB to open a video file. To make good use of memory, “VideoReader” only loads one frame of video at a time. The source of the video is [11], and the reading result is shown in Figure 3.

Figure 3: Monocular camera video reading results

There are many ways of lane segmentation and detection. One method involves the use of a bird's-eye image transformation. Despite the computational costs involved, this conversion provides a major advantage. The lane markings in the aerial view are uniform in thickness, simplifying the segmentation process. Lane signs belonging to the same lane also become parallel, making further analysis easier. Given the camera settings, the “BirdSeyView” object converts the original image to a bird's eye view as Figure 4. When the camera mount height is specified in meters, the vehicle coordinate unit is established from the single lens object. For example, if the height is specified in millimeters, then the rest of the simulation will use millimeters.

Figure 4: A bird's eye view after the conversion

2.2 Lane Detection

After obtaining the bird's-eye view from the pre-processing, we further used the "SegmentLaneMarkerRidge" function of Matlab to separate lane marker candidate pixels from the road surface. This technique was chosen because of its simplicity and relative effectiveness. Similar segmentation algorithms include semantic segmentation [12] and Steerable filtering [13]. The binary-value diagram of the processed lane line is shown in Figure 5 below.

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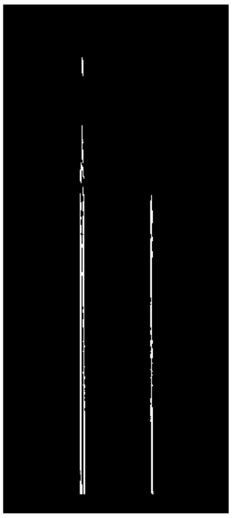

Figure 5: Binary map of lane lines

Next, we located the lane line in the body coordinate system anchored to the camera coordinates. Commonly used lane line models include cubic polynomial model or spline curve model. In this paper, a secondary lane line model is used to represent lane lines, as shown in Equation 1. The lane line curvature error caused by perspective distortion can be eliminated by transforming the lane line image coordinate into the car body coordinate system.

$$y = ax^2 + bx + c \tag{1}$$

The lane line model is applicable to the lane line identification in the driving path of vehicles. The lane line in the driving path or the signs painted on the road will not be recognized as the lane line. Since the split points contain outliers that do not belong to the actual lane lines, it is necessary to use MATLAB's "RANSAC" function to fit the curve, return the lane lines' edges and the parameters of the quadratic model (a,b,c), and store the parameters in the "boundaries" of the "parabolicLaneBoundar" object. The heuristic method for classifying lane lines into single/double, solid/dashed lines is listed in the auxiliary functions at the end of the example by setting the lane line intensity threshold based on the Region of Interest (ROI) and image size. Identifying the type of lane line is important for automatic vehicle steering. Figure 6 shows the solid/dashed lines and single/double lines identified in MATLAB.

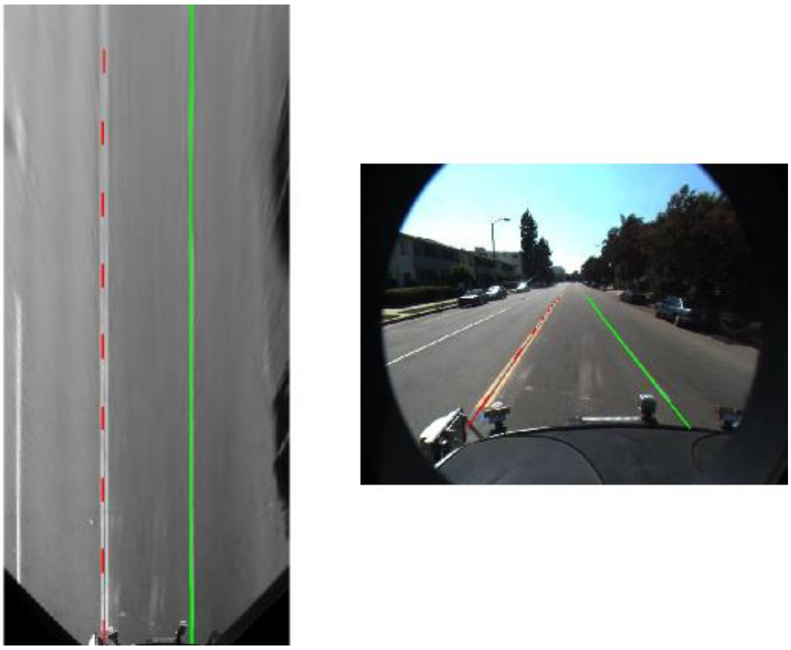

Figure 6: Lane line detection results display

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2.3 Vehicle Detection

Vehicle detection and tracking is the key to front collision warning (FCW) and autonomous emergency braking (AEB) system [14]. The trained ACF detection operator is loaded to detect the front and rear of the car. Such a detection operator can handle important collision alerts. The next step is to convert the vehicle detection position to the vehicle coordinate system. MATLAB's "Computevehiclelocations" function calculates the position of the vehicle in the vehicle coordinate system after detecting the vehicle frame detected by the detection algorithm in the image coordinate system, and returns the center position at the bottom of the detection frame in the vehicle coordinate system. Since we only used monocular camera and simple homography transformation, only the distance information along the road can be accurately calculated. The detection result is shown in Figure 7.

Figure 7: Vehicle identification and positioning results display

3. Findings

In this research, 100 frames of images in the video were selected as the test sample to test the accuracy of above road detection method in MATLAB. The recognition accuracy obtained is shown in Table 2 below.

Table 2: Test results

Types	Accuracy ratio
Single/dual lane detection	95%
Real/dashed lane detection	97%
Lane detection	99%

The error test results show that the monocular camera road detection method based on MATLAB established in this paper has a high recognition accuracy, and has a certain practical value.

4. Conclusions

Object Detection is a hot topic in the field of Computer Vision, which is widely used in road Detection. The research content of this paper is the core functions of Advanced Driving Assistance System (ADAS): lane line detection and vehicle recognition. The subject selects an image collected by a monocular camera for simulation, realizes Canny image preprocessing and Hough line detection through MATLAB software, and divides the recognition threshold according to the ROI region. The recognition rate of the algorithm for the single/double lane is 95%, the recognition rate for the virtual/solid line is 97%, and the recognition rate for the vehicle is 99%. The results show that the lane detection algorithm used in this paper can complete the lane line detection and vehicle identification well, and has high identification accuracy and good practical value.

The proposed the monocular camera road detection method is not applicable for binocular, camera, and the research of this paper is focused on image processing to detect, for deep learning training process,

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adopted has trained network model directly, so can be aiming at different algorithms in deep learning in the follow-up work, such as CNN, RCNN, and Faster - RCNN, comparison and optimization, which have higher precision of the model.

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