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AUTOMATIC LANE LINE DETECTION USING AI

Tejaswini TS[*1], Nithyashree R[*2], Vishrutha MR[*3], Vanditha AB[*4], Rahul PM[*5]

[*1,3,4,5]Student, Department Of Computer Science, Malnad College Of Engineering, Hassan, Karnataka, India.

[*2]Assistant Professor, Department Of Computer Science, Malnad College Of Engineering, Hassan, Karnataka, India.

ABSTRACT

Lane line detection is a crucial aspect in promoting road safety, facilitating autonomous driving, and enabling advanced driver assistance systems (ADAS). To achieve this, computer vision algorithms and image processing techniques are employed to identify and track lane boundaries on the road. The detection process involves several stages, including image acquisition, pre-processing, feature extraction, and localization of lane lines. Overcoming challenges such as varying lighting conditions, occlusions, and road surface changes has led to the development of various algorithms and approaches. Recently, deep learning techniques, particularly convolutional neural networks (CNNs), have gained significant attention in lane line detection due to their exceptional performance in accurately detecting and segmenting lane lines from input images or video streams. Moreover, the application of semantic segmentation models and instance-aware segmentation algorithms has allowed for distinguishing different types of lane markings, including solid lines, dashed lines, and turn lanes.

Keywords: Advanced Driver Assistance Systems (ADAS), Preprocessing, Convolutional Neural Networks (CNNS), Computer Vision Algorithms.

I. INTRODUCTION

Lane detection plays a crucial role in advanced driver assistance systems (ADAS) and autonomous vehicles. The objective of this project is to develop robust algorithms for accurately detecting and tracking lanes on roads. By analyzing real-time footage from the vehicle's onboard camera, these algorithms identify lane boundaries and provide precise lane position information. This technology enables features like lane departure warning, adaptive cruise control, and independent lane keeping, thereby enhancing driving safety. The project incorporates computer vision techniques such as edge detection, Hough transform, and image processing algorithms to extract line information from video frames. Additionally, deep learning approaches, specifically Convolutional Neural Networks (CNN), are utilized to improve accuracy and generalize the system's performance. Extensive testing is conducted under various road conditions to ensure the reliability and adaptability of the developed systems in real-world scenarios. Ultimately, the project aims to contribute to the development of intelligent transportation systems and pave the way for autonomous driving.

One of the main challenges in automatic lane detection for ADAS is the complexity of the lane patterns, perspective distortion, low visibility of lane lines, shadows, occlusions, brightness variations, and light reflections. To address these challenges, the proposed system employs computer vision-based technologies for lane boundary detection. In this paper, we present a system that efficiently identifies lane lines on smooth road surfaces. The central part of our approach involves applying gradient and HLS thresholding techniques to detect the lane lines in binary images. Furthermore, we utilize a sliding window search technique to estimate the color of the lane, enabling visualization of the detected lanes. Traditional computer vision-based lane detection methods primarily rely on image processing algorithms to extract lane line features. These methods involve reducing image channels, performing grayscale conversion, applying edge detection algorithms like Canny or Sobel, extracting relevant features, and performing lane line fitting using models such as cubic polynomials, spline curves, or arc curves. The input to our system consists of video streams recorded by the vehicle's camera, which are processed using Hough Line and Hough Transform algorithms for lane mark detection.

Figure 1: Road scene image

II. LITERATURE SURVEY

[1]. Saha et al. [2012] discussed an algorithm for detection of marks of road lanes and road boundary by using intelligent vehicles. It converted the RGB road scene image into gray image and employed the flood-fill algorithm to label the connected components of that gray image. After that the largest connected component obtained by the algorithm and which was the road region was extracted. The unwanted region was detected and subtracted like outer-side of the road. The extracted connected component was filtered to detect white marks of road lane and road boundary. The road lane detection algorithm still had some problems such as critical shadow condition of the image and color of road lanes other than white.

[2]. Tseng et al. [2005] gave a lane marking detection algorithm by using geometry information and modified Hough transform. In that algorithm the captured image was divided into road part and non-road part by using camera geometry information. The color road image was quantized into a binary image. The modified Hough transform with road geometry consideration was used to detect the lane markings. The histogram of intensities was applied to quantize the road image into a binary image. A modified Hough transform method has been developed to detect the lane markings in road image by using the road geometry information. It was time consuming because Hough transform was a full search algorithm in parameter space. It also failed when the lane boundaries intersected in a region which was a non-road part.

[3]. Shen et al. [2012] discussed a monocular vision system that could locate the positions of the road lane in real time. An algorithm proposed for lane detection using single camera. The algorithm worked in five steps. Initially edge detection was done to find all present edges from road image as road line required was included in it. Canny approach has been used to achieve the edge map from road image for its accurate edge detection. Then matching was done to eliminate unwanted figures. A priority and orientation based searching method has been used for enhance and label potential lane segments from edge map, degrading unwanted edge features. Based on results from search, a linking condition was used to assemble matched segment that further strengthen the confidence of the potential lane line. Finally a cluster algorithm was used to localize the road-lane lines.

[4] M. Dhana Lakshmi et al. [2012] discussed a novel algorithm to detect white and yellow colored lanes on the road. An automatic lane marking violence detection algorithm was designed and implemented in real time. The lane detection method was robust and effective in finding the exact lanes by using both color and edge orientations. The color segmentation procedure identified the yellow and white colored lanes followed by edge orientation in which the boundaries was eliminated, regions was labeled and finally the lanes was detected. As the height of the camera was relatively constant with respect to the road surface, the road portion of the image can be exclusively cropped by providing the coordinates, so that identifying the lanes became much more efficient.

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III. MOTIVATION

Fully self-driving passenger cars are not on the immediate horizon, despite claims made by individuals like Elon Musk, who suggest that Teslas will achieve "full self-driving" capabilities by the end of 2020. While Tesla's hardware may be prepared for autonomous driving, significant work remains to be done on the software front. Many talented scientists are actively engaged in developing the necessary updates. As human drivers, our natural inclination is to look ahead and make decisions about the car's path—its direction, the space between lines, and so on. With every autonomous vehicle equipped with a front-facing camera, a critical task is to determine the boundaries within which the car should operate. Just as humans draw lines on roads, we aim to train autonomous vehicles to "see" these lines and accurately detect lanes under different weather conditions.

IV. PROPOSED SYSTEM

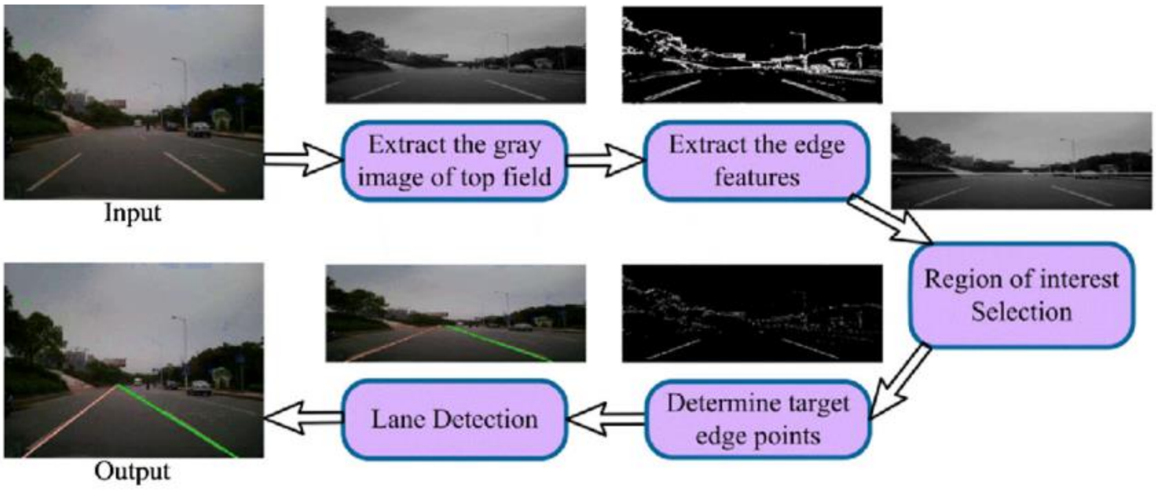

Figure 2: Block Diagram of lane line detection system

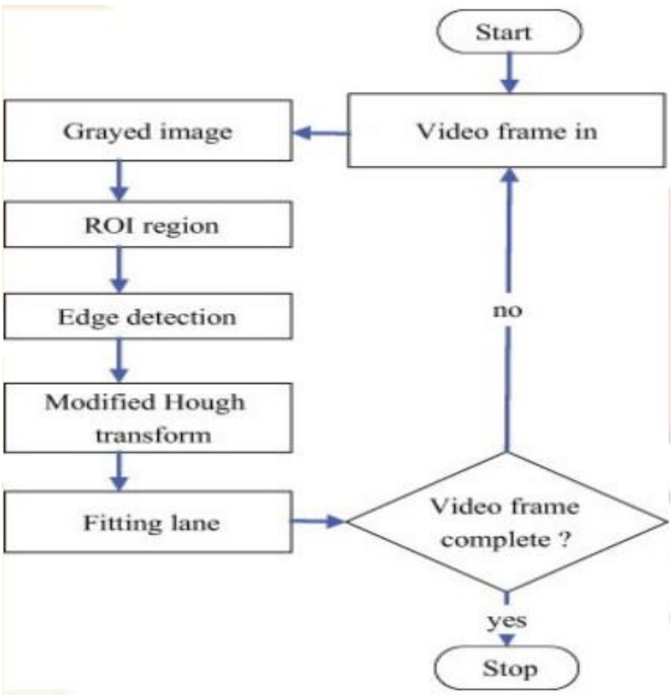

Figure 3: Flowchart of lane line detection system

Methodology in Detail:

This model uses video pictures obtained from the road by a camera positioned inside the automobile to determine road lines in real time. The camera is mounted inside the vehicle behind the windscreen and almost in the centre to offer a view of the road. The suggested approach for determining road lines involves three steps: pre-processing, area selection, and road line determination. Pre-processing steps include noise reduction, RGB to greyscale conversion, and input picture binarization. Then, a polygonal region in front of the automobile is picked as the area of interest due to the presence of road lines in that area. The third stage uses the Canny edge detection technique to identify the image's edges inside the region of interest, and the Hough transform to identify the road's major lines.

A. Pre-processing: Preprocessing plays a crucial role in image processing as it involves several techniques and operations that are applied to raw images before performing more advanced tasks. The purpose of preprocessing is to enhance image quality, remove noise, and extract relevant information to improve the effectiveness of subsequent processing steps. To minimize algorithm computations the input image is converted into grayscale image which is needed for Canny Edge Detection.

Figure 4: Grey Scale Convertion

B. Canny Edge Detection: Canny edge detection plays a crucial role in identifying and extracting the lane lines from an image or video stream. Canny edge detection operator uses the horizontal and vertical gradients of the pixel values of an image to detect edges. It is an edge detection algorithm that uses a multiple stage algorithm so as to detect edges in images. Its aim is to discover the optimal edge detection. It also includes a noise reduction step using a Gaussian filter, which helps in smoothing the image and reducing noise. This ensures that the algorithm focuses on detecting the actual lane lines rather than noise artifacts, which helps localize the detected edges more precisely. It ensures that only the local maxima (strongest edges) are retained, while suppressing weaker responses. This step helps in refining the detected edges and making them thinner.

Figure 5: Canny Edge Detection

C. Region of Interest: The lines that are not in the region of interest are masked. Also, the region of interest is found by removing unnecessary things present on the road. The road lines are visible in front of and on both sides of the automobile in the photos received from the road surface. The region of interest is a dynamic polygonal 8 section of the picture in front of the automobile that was chosen using a trapezoidal mask. The information about the image's vanishing point is utilized to construct the trapezoidal mask. A trapezoid is formed in the bottom portion of the vanishing point that encompasses the region directly in front of the automobile. The Figure illustrates a mask created for the input picture sample in which the portion of the image corresponding to the region of interest is one, and the remainder is zero. By applying this mask to the input binary picture, the preferred region is picked, containing the road lines just in front of the automobile. The output binary picture in Figure results from applying the designed mask to the input binary image.

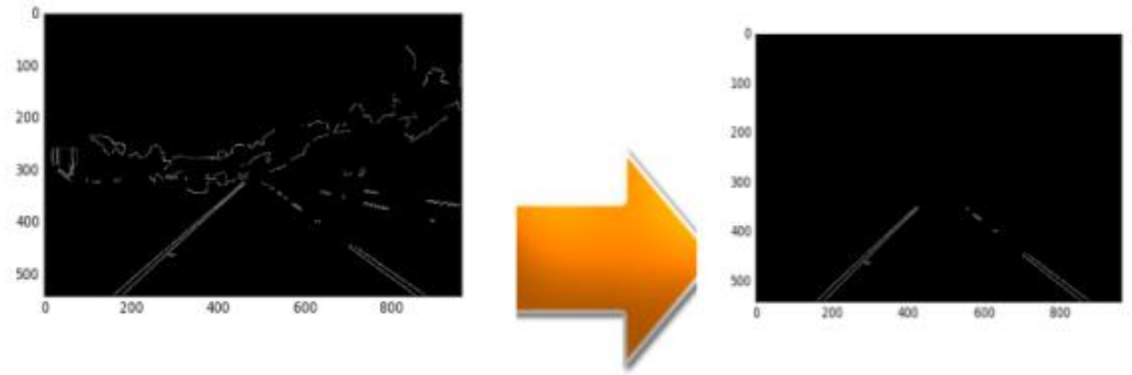

Figure 6: Region of interest

D. Hough Transform: The Hough transform is a technique in which features are extracted that is used in image analysis and digital image processing. Previously the classical Hough Transform worked on the identification of lines in the image but later it has been extended to identifying positions of shapes like circles and ellipses. In automated analysis of digital images, there was a problem of detecting simple geometric shapes such as straight lines, circle, etc. So, in the pre-processing stage edge detector has been used to obtain points on the image that lie on the desired curve in image space. But due to some imperfections in image data or in the edge detector, some pixels were missing on the desired curve as well as spacial deviation between the geometric shape used and the noisy edge pixels obtained by the edge detector. So to refine this problem Hough transform is used. In this the grouping of edge pixels into an object class is performed by choosing appropriate pixels from the set of parametric image objects. Using this technique, we can find lines from the pixel outputs of the canny edge detection output. This finally provides the desired output.

Figure 7: Hough Transform

E. Lane Fitting:

Lane fitting is an essential step in lane line detection projects. It involves identifying and modeling the lane lines in an image or video stream to estimate their positions and shapes. Evaluate the quality of the lane fit by measuring the goodness of fit metrics such as residuals, R-squared value, or mean squared error. If the fit is not satisfactory, you may need to adjust the fitting parameters or refine the process.

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V. RESULTS AND DISCUSSION

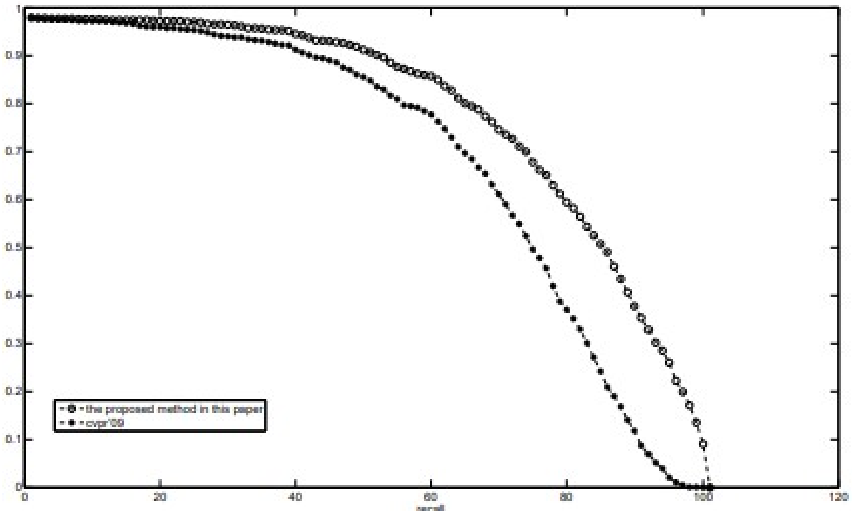

Figure 8: Road segmentation accuracy: combination of texture and color features improves the accuracy over texture-feature based method.

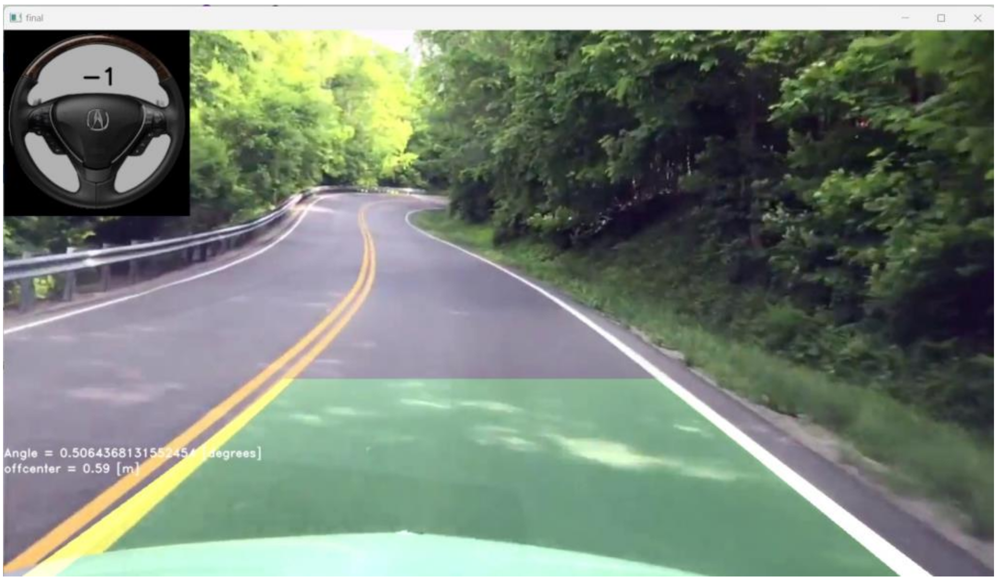

Figure 9: Detected road lane line with steering angle

VI. CONCLUSION

When we drive, our eyes guide us in choosing the right path. The lane lines on the road serve as constant markers, indicating where we should steer the vehicle. In the development of self-driving cars, one of the initial goals is to automatically detect these lane lines using algorithms. However, it's important to ensure flexibility in determining the region of interest (ROI) for road detection. For instance, when driving on steep inclines or encountering tight turns or heavy traffic, the horizon may shift and no longer correspond to the frame's proportions. This project focuses entirely on image processing and road detection for self-driving vehicles, which holds immense potential for the future. We have successfully implemented specific algorithms that enable clear road detection. It is crucial for people to change their perception of self-driving cars and recognize their safety. These cars are already secure and constantly improving in terms of safety. By embracing technology and giving it a chance, individuals can enjoy the convenience of automated driving. Driverless cars represent a significant advancement in transportation technology. They offer an all-encompassing media experience while ensuring safety. The development of autonomous vehicles continues, with ongoing software updates. From initial driverless concepts to the integration of radio frequency, cameras, and sensors, more semi-autonomous features are emerging. These advancements will lead to reduced congestion, increased safety through faster reactions, and fewer errors.

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