



Road Boundary Extraction Based on Blue Color Segmentation of Digital Images

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Received: 15/8/2026 Revised: 17/8/2026 Accepted: 20/9/2026 Publication: 13/10/2026

Abstract

Road edge extraction is a basic task in computer vision applications in last decades , including autonomous navigation, intelligent transportation systems, and driver assistance systems. This paper presents a method for extracting road edges from digital images which it has a lot of environment objects, like stones, trees, and road besides, others. This approach based on image segmentation of input image called blue color segmentation. The proposed approach begins by preprocessing filtering, converting the input image into an appropriate color space, followed by isolating the blue-colored regions that represent the road boundaries or markings. Thresholding techniques are then applied to generate a Gradient binary mask that highlights the road edges. Morphological operations and edge detection filters are subsequently used to refine the extracted edges and remove noise. The performance of the proposed method is evaluated on a set of digital road images under varying lighting and environmental conditions. Experimental results demonstrate that blue color segmentation provides an effective and computationally efficient means of extracting road edges and overlapped on input image, achieving satisfactory accuracy compared to traditional edge detection methods and others, like textures it has complicated calculations. This proposed approach is simple to implement and suitable towards real-time applications.

Keywords: Road Edge Extraction, Color Segmentation, Blue Color Detection, Digital Image Processing, Edge Detection, Computer Vision.

الملخص:

يُعدّ اكتشاف مسارات الطريق عنصرًا أساسيًا في أنظمة النقل الذكية الحديثة وتطبيقات القيادة الذاتية. حيث تقدّم هذه الورقة البحثية طريقة فعّالة وقوية لاستخلاص مسارات الطريق من الصور المدخلة، وذلك بالاعتماد على الخصائص المميزة لعلامات المسار ذات اللون الأزرق. تبدأ الطريقة المقترحة بالحصول على الصورة، تليها مراحل المعالجة المسبقة التي تشمل تقليل الضوضاء وتوحيد الإضاءة بهدف تحسين جودة الصورة. بعد ذلك، يتم تحويل الصورة من فضاء الألوان RGB التمثيل اللوني أكثر ملاءمة لتعزيز التمييز بين الألوان وتُطبّق تقنية العتبة اللونية لعزل المناطق الزرقاء التي تمثل علامات المسار. ولتحسين النتائج بشكل أكبر، تُستخدم العمليات المورفولوجية لإزالة الضوضاء وملء الفجوات داخل المسارات المكتشفة كما يتم استخدام تقنيات كشف الحواف والترشيح المعتمد على المناطق لتحديد حدود المسارات بدقة والتخلص من الأجسام

غير المهمة. حيث تُظهر الطريقة المقترحة أداءً قويًا في ظروف إضاءة مختلفة وخلفيات معقدة، مع الحفاظ على دقة عالية في الاكتشاف وتكلفة حسابية منخفضة. تشير النتائج التجريبية إلى أن هذه الطريقة مناسبة للتطبيقات الزمنية الحقيقية (Real-Time)، خاصة في البيانات التي تكون فيها علامات المسار واضحة ومميزة باللون الأزرق. وتبرز هذه الدراسة أهمية تقنيات التقسيم المعتمدة على اللون كأداة بسيطة وفعالة لاستخلاص مسارات الطريق، مما يوفر حلاً عملياً لتعزيز موثوقية أنظمة المساعدة على القيادة المعتمدة على الرؤية الحاسوبية.

Introduction

Road edge extraction is a main component in modern computer vision applications, particularly in intelligent transportation systems (ITS), autonomous driving technologies, and advanced driver assistance systems (ADAS). The ability to accurately identify and track road lanes enables vehicles to maintain proper alignment, avoid unintended lane departures, and enhance overall driving safety. As the demand for automation in transportation continues to grow, the development of efficient and reliable lane detection techniques has become an important research focus. In practical scenarios, road environments present numerous challenges that complicate the process of lane detection. These challenges include varying illumination conditions, shadows cast by surrounding objects, road surface irregularities, and the presence of noise or occlusions such as vehicles and pedestrians. Traditional lane detection methods, which often rely on grayscale conversion and edge detection techniques, may fail to deliver consistent performance under such conditions. Consequently, there is a need for more robust approaches that can effectively handle environmental variability[1],[9].

Color-based image processing has emerged as a promising solution to address these challenges. Unlike grayscale methods, color analysis provides additional information that can be used to distinguish lane markings from the surrounding road surface. In particular, the blue color channel has shown effectiveness in enhancing the contrast between lane markings and the background in certain road scenes. This research focuses on exploiting the blue channel to extract lane features from the input image pic33.jpg, which represents a realistic road scenario captured under natural conditions[9].

The image pic33.jpg contains typical elements found in road environments, such as lane markings, road texture, possible shadows, and surrounding objects. These elements introduce complexity in the detection process, making it necessary to adopt a method that can isolate relevant features while minimizing the impact of noise. By analyzing the distribution of color intensities in the blue channel, it becomes possible to highlight lane markings that may not be as distinguishable in other channels. This characteristic makes the blue channel particularly useful for segmentation tasks in lane detection. To improve the effectiveness of the proposed method, several preprocessing steps are applied to the input image. These steps include noise filtering, contrast enhancement, and normalization, which collectively improve image quality and prepare it for further analysis. After preprocessing, the blue channel is extracted from the RGB image, and thresholding techniques are applied to separate potential lane regions from the background. This segmentation process simplifies the image and reduces the amount of irrelevant data. Following segmentation, morphological operations such as dilation and erosion are used to refine the detected regions. These operations help to remove small noise components and fill gaps within the lane markings, resulting in more continuous and accurate representations. Furthermore, to identify the geometric structure of the lanes, techniques such as the Hough Transform can be employed to detect straight or slightly curved lines corresponding to lane boundaries[2].

The use of the blue channel offers several advantages, including reduced sensitivity to certain lighting variations and improved distinction between lane markings and road surfaces in specific

conditions. However, it is important to acknowledge that this approach may not perform equally well in all scenarios. For instance, in cases where lane markings do not exhibit strong blue channel characteristics or where lighting conditions significantly alter color perception, detection accuracy may decrease. Therefore, this research also considers the limitations of the method and highlights the need for adaptive or hybrid approaches[11].

This paper aims to develop a practical and efficient lane detection method based on blue channel analysis and apply it to the input image pic33.jpg. By focusing on color-based segmentation and incorporating preprocessing and post-processing techniques, the proposed approach seeks to achieve reliable lane detection in complex environments. The simplicity of the method also makes it suitable for real-time applications, where computational efficiency is a key requirement.

The proposed method follows as :

1. Image acquisition
2. Preprocessing
3. Blue channel extraction
4. Thresholding
5. Morphological refinement
6. Edge detection
7. Line detection (Hough Transform)
8. ROI selection
9. Final visualization

Methodology :-

1. Input Image Acquisition

The process begins with acquiring the road image (pic33.jpg), which represents a real-world driving scenario. The image typically contains lane markings, road texture, shadows, and possible surrounding objects such as vehicles or roadside elements like figure 3.1. Since the input image is originally in the RGB color space. To improve color discrimination, the image is analyzed with emphasis on the **blue channel**, which enhances the visibility of lane markings as in figure 3, one of problems for detecting road lines front of vehicle, multi lines roads, and cars, pedestrians so this algorithm investigate the proper lines in lower half of image front autonomous vehicle[1] .



figure 3.1 Surrounding objects such as vehicles or roadside elements

The robust technique used to detecting road lanes for input image leverages color-based segmentation, focusing on blue lane markings, and incorporates preprocessing, morphological filtering, edge detection, and geometric lane extraction. The overall approach is designed to be

robust under varying lighting conditions, multi lines roads, and shadow images to produce accurate lane boundaries while minimizing computational complexity



Figure 3.2 Input image

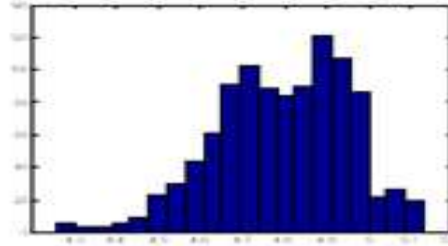


figure3.3 histogram of input image

To measuring the distribution of grayscale intensity of input image using histogram and its clear from figure 2. Its obvious the input image figure 3.2 is a high-resolution road scene captured using a forward-facing camera mounted on a vehicle[1]. The image basically contains:

Blue-colored lane markings, Surrounding road surfaces and pavement Shadows, reflections, and other road objects such as vehicles. The complexity of the image makes it suitable for evaluating the robustness of the blue color-based lane extraction method.

2- Processing of Input Image

The processing of the input image is an essential stage in the road lane detection system. Its main purpose is to prepare the image for accurate extraction of lane markings by improving image quality and reducing unwanted information. In this research, the input image undergoes several sequential processing steps to ensure reliable lane detection. The first step is noise reduction because the acquired image may contain unwanted noise caused by lighting conditions, camera sensors, or environmental effects. noise reduction techniques which used smoothing filters are applied to remove small disturbances while preserving important lane features. The second step is illumination adjustment used to improve the input image appearance, because variations in brightness and shadows can affect lane visibility. Therefore, Adaptive Histogram Equalization (CLAHE) is a common image enhancement technique used to improve local image contrast instead of processing whole the image and it's capability works well under non-uniform lighting ,prevents over-amplification of noise , and enhances lane visibility in shadowed regions. So the input image It redistributes the intensity values of the image, making dark regions brighter and bright regions more balanced, and this type of processing widely used in autonomous vehicle guiding .

3-blue channel extraction and thresholding:

Blue color extraction is an important stage in the proposed lane detection system because the lane markings in the input image are distinguished by their blue color characteristics. The main objective of this stage is to isolate the blue lane regions from the rest of the image to simplify the lane detection process[11].

3.1- Blue Channel Extraction

The input image is initially represented in the RGB color space, which consists of three color components: Red (R), Green (G), and Blue (B) as in figure 3.. In this research, the blue channel is extracted separately because it provides better contrast between the lane markings and the road surface.

The extraction process involves selecting only the blue intensity values from the RGB image while suppressing the red and green channels. As a result, regions containing blue lane markings appear brighter, whereas non-relevant regions become darker. This enhancement makes the lane features easier to detect and analyze. The blue channel was chosen because:

- It improves lane visibility in the input image.
- It reduces the influence of unwanted background details.
- It enhances discrimination between lane markings and surrounding road textures.

3.2-Thresholding

The problems it face the vision application spatially in autonomous vehicle driving, it is useful to be able to separate out the regions of the image corresponding to objects in which we are interested, from the regions of the image that correspond to background. Thresholding often provides an easy and convenient way to perform this segmentation based on the different intensities or colors in the foreground and background regions of an image. There are many types of thresholds global, local, and adaptive (dynamic) thresholding. The key issue here is how to choose an optimal threshold value so that the number of misclassified image pixels is kept as low as possible. Theoretically, we can determine the optimal threshold value according to the Byes rule if we know the pixel value distributions of foreground and background classes . However, in practice we know only a mixture of the two distributions, or the pixel value histogram of an image, but not the two separate distributions, so we may have to make some assumption, determine the optimal threshold according to the statistical decision theory. Figure 3.4 shows the histogram of two objects in an image with multiple thresholds. But in this research I will to apply one threshold on blue color image to extract the interesting objects(edges) from input image. After extracting the blue channel, a thresholding technique is applied to segment the lane markings from the background. The idea is used here applied on low half input image(ground region), thresholding converts the grayscale blue-channel image into a binary image by comparing each pixel intensity with a predefined threshold value [1].

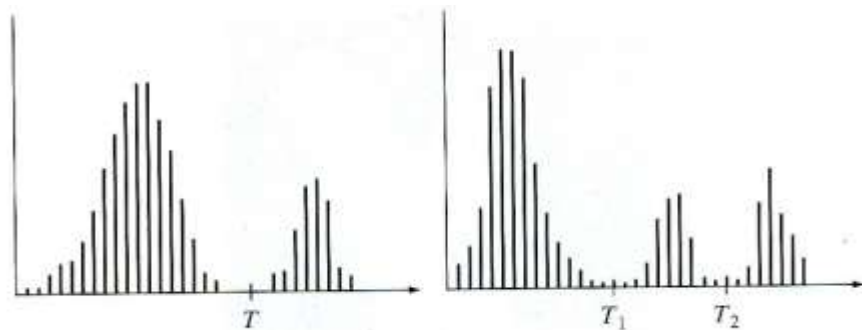


Figure 3.4 Threshold fitting between two and three classes

- Pixels with intensity values greater than the threshold are classified as lane regions.
- Pixels with lower intensity values are considered background and removed.

This process highlights the lane markings while suppressing irrelevant areas, the output of thresholding is a binary image, white pixels represent the detected lane markings and black pixels represent the background. Thresholding significantly reduces image complexity and prepares the image for further processing stages such as morphological operations and edge detection. Using thresholding in blue color images useful in processing and has more advantages like, Simplifies lane segmentation, Enhances detection accuracy, and Reduces computational complexity . After noise removal and image enhancement, the Canny edge detection algorithm is applied to identify the boundaries of the road lane markings. The Canny operator is widely used in computer vision applications (3.3), (3.4) due to its high detection accuracy and robustness against noise[3],[6].

This equation used to detect strong edge value in each pixel called gradient magnitude[3]

$$M(x,y)=\sqrt{I_x^2+I_y^2} \quad (3.1)$$

$$M(x,y)=\sqrt{I_x^2+I_y^2} \quad (3.2)$$

Horizontal Gradient Mask (Gx)

$$G_x = \begin{bmatrix} -1 & 0 & 1 \\ -2 & 0 & 2 \\ -1 & 0 & 1 \end{bmatrix} \quad (3.3)$$

Vertical Gradient Mask (Gy)

$$G_y = \begin{bmatrix} -1 & -2 & -1 \\ 0 & 0 & 0 \\ 1 & 2 & 1 \end{bmatrix} \quad (3.4)$$

After calculating the gradient magnitude and direction, non-maximum suppression is applied to thin the edges. Finally, double thresholding is used: $M(x,y) > T_H$ Strong edge, $T_L < M(x,y) < T_H$ Weak edge, $M(x,y) < T_L$ Non-edge pixel where: (T_H) = High Threshold, (T_L) = Low Threshold

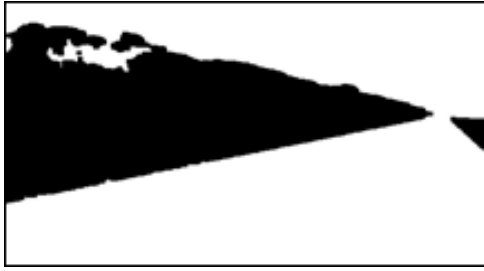
The resulting binary edge image contains white pixels representing detected edges and black pixels representing the background as in figure 3.6. These edges are subsequently used for lane extraction through the Hough Transform of lower half image means represents the interested image and road lane marker[4],[5],[6] . The next step to process the result image by morphological image processing open and close functions to remove all small and unconnected objects, close holes as shown in figure 3.7[1].



Figure,3.5 blue Chanel image



figure,3.6 thresholded blue segmentation



Figure, 3.7 morphological operations results



Figure, 3.8 Over lay extracted lines on the input image

Then, the next step to over lay the extracted road lines on the input image as shown in figure, 3.8 [7]

Conclusion:-

In this work, a road lane detection system was developed using image processing techniques in MATLAB. The proposed approach relies on blue color segmentation to identify lane markings from images captured by a front-facing vehicle camera. The RGB image was first converted to the HSV color space, which provides better color discrimination under varying illumination conditions. A thresholding process was then applied to isolate the blue lane markings and generate a binary image.

To improve detection accuracy, morphological operations were used to remove noise and enhance the segmented regions. Subsequently, the Canny edge detector was applied to extract significant edges, and the Hough Transform was utilized to identify the lane boundaries. The detected lane lines were then used to estimate the vehicle's position relative to the road and determine its position.

Future Work:-

Several improvements can be implemented in future work to enhance the performance and robustness of the proposed lane detection system. First, adaptive thresholding techniques can be employed to improve blue color segmentation under varying lighting and weather conditions. Second, advanced image enhancement methods may be incorporated to increase detection accuracy during nighttime driving and in the presence of shadows.

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