Dangerous Road Curvature Detection Using Edge Device

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Abstract—**This paper talks about the usage of edge devices and image processing techniques to detect unsafe road curvatures in real-time, presenting a novel way to improve road safety. There is a critical need for automated systems to notify drivers ahead of time of road conditions due to the rising incidence of collisions caused by drivers' lack of awareness, particularly on curving routes. Our technology uses edge computing capabilities to evaluate real-time video streams from roadside sensors or onboard cameras, extracting pertinent information to identify potentially dangerous curves. To precisely define road geometry, the suggested image processing pipeline uses curve fitting, feature extraction, and edge detection methods. The curvature radius, gradient, and contextual information methods are used to discern between normal and harmful curves using a combination of machine learning models and conventional computer vision approaches.**

Keywords—Lane markers, Thresholding, Navigating, Efficiency, Edge detection, Line detection, Image processing, Driver safety

I. Introduction

In the transportation industry, autonomous cars hold great promise due to their efficiency and safety benefits. For a self-driving car to navigate streets without much assistance from people, it must have awareness of its surroundings. One of the most popular topics in car research is systems for passenger and driver safety. Lane keep and steering assist are two examples of the technologies that allow automobiles to recognize lanes, keep the vehicle as aligned with the road as possible and assist with turning. Fewer works are presented on unmarked roads than on well-structured roadways with appropriate lane markers. This paper reviews two of these approaches. They are predicated on methods for processing digital images. It entails modifying photos using a variety of computer methods. This is done in order to produce an image that meets the necessary specifications, such as increased details, sharpness, clarity, and reduced noise for effective extraction and analysis. Thresholding, Warping, and Region of Interest are the steps that both techniques share (ROI). Subsequent processing involves the use of particular methods for Pixel Summation (Histogram), Gaussian Blur, Image Dilation, Canny Edge Detection, and Sliding Window algorithm[1]. In addition, lane detection contributes significantly to the lane departure warning system. The two primary components of lane detection tasks are edge detection and line detection. In the process of lane detection, line detection is just as crucial as edge detection[2]. If such unsafe driving conditions are identified early and other drivers are notified, an increasing number of incidents can be prevented. For the most part, speed sensors, cameras, and roadways are used to track and identify vehicles who go faster than the posted limit on public roads and highways. This straightforward method has no limitations[3].

II. Working Procedure

A. Thresholding

As the method is intended for unmarked roads, color thresholding is used to identify the color of the road rather than lane markings.The image acquired from the video feed is not immediately subjected to thresholding. Blue Green Red (BGR) images from video feeds are converted to Hue Saturation Value (HSV) images because it is superior for object or color detection. The HSV color space illustrates how colors react to light. The three matrices that make up HSV mathematically are called "Hue," "Saturation," and "Value," and their respective ranges are 0-179, 0-255, and 0-255. HSV is mostly utilized for color-based image segmentation, which is how the road and its surroundings are separated in both methods. Limiting will change[1].

B. Warping

The viewpoint of the image captured by the camera module is skewed. This image alone cannot be used to pinpoint the lane edges correctly. The idea of warping is applied to correct this image. By altering the image's viewpoint, image warping is utilized to provide a top or bird's-eye view of the path. Perspective transformation modifies an image's or video frame's perspective to more effectively obtain specific insights. Over the image, a collection of points is supplied for warping. The Region of Interest (ROI) will be determined by the values of these locations. The image or video frame's viewpoint is changed by these two sets of points. By providing these coordinates to OpenCV library functions, it is accomplished. The end product would be an image with a bird's eye perspective and cropped according to the ROI. One of the most popular preprocessing methods for lane detection systems is warping, which yields an image that makes additional computations simpler than with the original camera-derived image. Getting a rectangle shape while the road is straight is the main notion[1].

C. Pixel Summation

Pixel summation is used to calculate the road's curvature. It involves multiple steps: To depict road features, the image is first converted to a binary form, using black and white pixels. After that, lane positions are mapped by lane detection using a histogram. A preset threshold is used to filter out pixels that represent noise. The middle point is represented by the overall average, and the base point is the average histogram value of the lower 1/4th of the image. The curvature value obtained by calculating the difference between these sites can be applied to tasks like curvature radius estimate and steering angle prediction[1].

D. Integrating Core Techniques for Effective Analysis

Color masking, edge detection, region of interest selection, and Hough line transform extrapolation are the four main techniques used in this work for road lane detection. Every approach has advantages and disadvantages and fulfills a specific function in the detecting process. This section outlines each method's salient characteristics and common uses in an easy-to-understand yet effective manner. The road lane detection problem is methodically broken down into functional modules, and each module's implementation strategy is explained[4].

E. Hough Transform

In image analysis, the Hough Transform is essential for recognizing lines and resolving issues with automated straight line and circle identification. between the evaluation of distinct equations for potential lines between picture points, it functions well even in the presence of noise and occlusion. It matches points to lines based on angle and distance from the origin by converting images to binary form and using Hough space. By increasing the number of votes for lines that intersect, an accumulator array finds lines. Although curved lane detection is commonly utilized for straight lanes, there is still need for improvement in this area. Additional research in this field has the potential to greatly increase the Hough Transform's adaptability and effectiveness in digital image processing[5].

III. ALGORITHMS

A.Color Space Conversion:

To make the image simpler, convert it from RGB to grayscale or another color format.
Method:
Gray(x, y)=0.299 x R(x,y) + 0.587 x G(x, y) + 0.114 x B(x,y).
Where R(x , y)B(x ,y) are the red, green and blue respectively.

B. Edge Detection:

To locate edges in the image, use Canny edge detection.

Edges(x,y) =	High	if Gradient(x,y)>=High threshold
	Low	if Gradient(x,y)<High threshold
	Non-edge	otherwise.

C. Hough Transform

In order to identify lines in the edge image, use the Hough transform.
Method:
Y=mx + c
m is slope and c is intercept.

IV. OBJECTIVES AND MOTIVATION

A. Objectives

i). Improve Road Safety: The main goal is to increase road safety by immediately identifying potentially hazardous road curves. Through the use of edge devices with image processing capabilities, the system seeks to lower the likelihood of accidents by rapidly warning drivers of potentially dangerous curves.

ii). Early Hazard Identification: One other goal is to identify possible risks as soon as possible, especially those posed by blind or steep curves in the road. The system can quickly scan live video feeds to identify and categorize hazardous curvature patterns, allowing for automated intervention systems or timely driver warnings. This is accomplished by utilizing image processing algorithms on edge devices.

iii). Accurate Detection and Classification: The system's goal is to precisely identify and categorize different kinds of hazardous road curves, such as abrupt changes in road alignment, blind corners, and sharp turns. This goal entails creating reliable image processing algorithms that can reliably and precisely discern between safe curves and typical road features.

iv). Real-time Alert Generation: The system works to provide drivers with real-time notifications when they approach hazardous road curves in order to ensure effective hazard reduction. Drivers can get timely signals by combining edge devices with responsive alert mechanisms, such as in-vehicle displays or connected mobile applications. This allows drivers to modify their driving behavior accordingly and ensure safe navigation.

B. Motivation

i) Enhanced Road Safety: Improving road safety is the main goal of employing edge devices and image processing to detect problematic road curvatures. This technology can inform drivers in real time to potentially dangerous road curves so they can adjust their driving style and lower their chance of an accident. Preventing injuries and saving lives on the roads is the ultimate goal.

ii) Preventative Measures: Preventative measures can be put into place by identifying potentially hazardous road curves. By providing advance notice, drivers can safely negotiate difficult road conditions by adjusting their speed or taking the appropriate safety measures. By taking this proactive measure, the possibility of accidents brought on by unanticipated or poorly indicated curves can be greatly decreased.

iii) Effective Allocation of Resources: Road curvature identification with image processing and edge devices allows for effective resource allocation. Computational operations can be completed locally by placing sensors and processing units near the network's edge, which minimizes latency and eliminates the need for a large infrastructure. This method preserves responsiveness while optimizing the use of resources.

iv) Adaptability to Different situations: This technology's ness to adapt to different situations serves as another motivator. Drivers are constantly at risk when they encounter hazardous curves, whether they are on freeways, rural roads, or city streets. The detection system can be implemented over various road networks, offering extensive coverage and enhancing driver safety for everybody, by utilizing edge devices and image processing.

V. EXISTING WORK

To understand key methods and algorithms, we first read through a number of publications in our investigation of relevant research. Among these, Hough line transform and Canny edge detection stood out as essential techniques that were routinely applied in several investigations. One paper, for example, used a bilateral filter for smoothing and the Hough Transform and Canny edge detection for road marking and border identification. Edge detection features like low response, localization, and good detection were highlighted. Another work, known for its computing efficiency and resilience, created Adaptive Road Mask employing Vanishing Point detection. To improve algorithm efficiency and accuracy, these approaches usually start with edge detection and Hough line transform, then go on to region-of-interest selection and picture preprocessing[6]. In order to detect lanes with high efficiency, Jae-Hyun Cho et al. (2014) used the Hough transform with optimized accumulator cells in the four ROI in parallel. Despite the fact that Hough Transform can only identify straight lines, the curve road's low lane recognition rate has been reasonably addressed[5].

VI. SYSTEM DESIGN

The first step in the process is the examination of road geometry, which entails looking at a variety of factors including curvature, slope, and width in order to fully comprehend the layout of the road. Finding difficult curves on the road is made easier with the help of this study. These bends put drivers at greater risk because of things like their sharpness, poor vision, or sudden direction changes. Roadside sensors or onboard cameras are just two examples of the edge devices that are strategically placed to identify these potentially dangerous portions. By gathering data on the road environment in real time, these sensors enable effective processing and analysis of road geometry and bends right at the edge. The system can quickly detect and react to hazardous road conditions by utilizing edge computing capabilities, which will ultimately increase overall road safety.

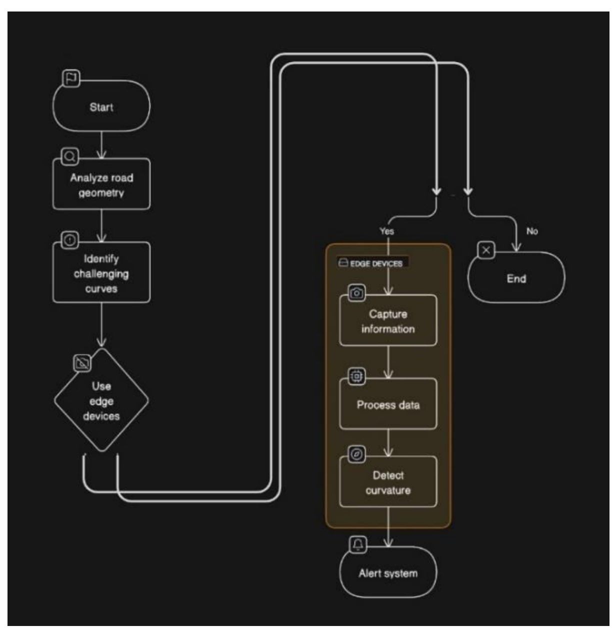

Fig 1. System Flow chart

VI. PROPOSED SYSTEM

By using edge devices and image processing to detect dangerous road curvatures in real-time, the proposed system seeks to improve road safety. Live video feeds from roadside sensors or onboard cameras are processed using edge computing to extract pertinent information for detecting hazardous curves. In order to precisely outline road geometry, the image processing pipeline includes edge detection, feature extraction, and curve fitting techniques. The system uses contextual information, curvature radius, gradient, and computer vision techniques to discriminate between dangerous and normal curves. Drivers can respond proactively to possible accidents by receiving timely alerts via in-car displays or connected mobile devices upon detection of a hazardous curve.

VII. RESULTS AND SNAPSHOTS

A. Real Image

Fig 2. Real image

Webcam will capture the image of road. But here we are using paper road instead of real road.

B. Processed image

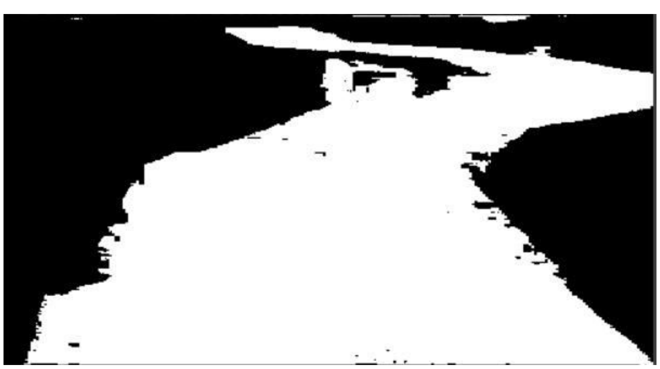

Fig 3. Processed Image

This will give the range of values that we need to use to find Our white paper path.

C. Thresholding

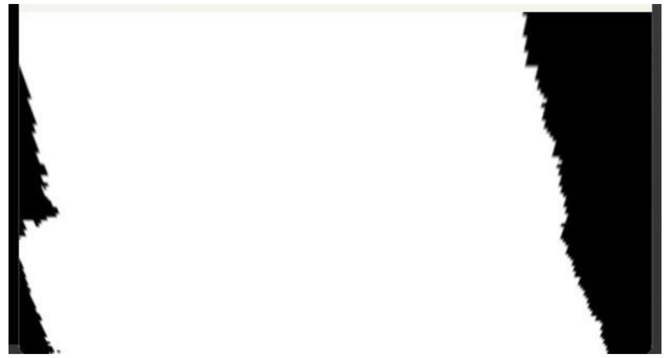

Fig 4.Thresholding

This will give the top view of above real image and it will convert into processed image.

D. Histogram and middle point

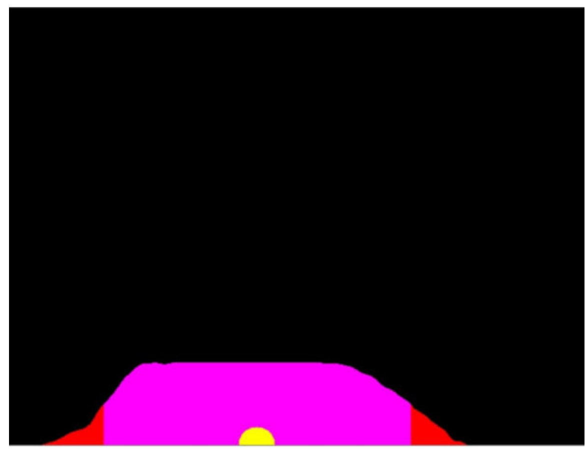

Fig 5. Histogram and middle point

Here we can see the histogram of the warped image on the right. The yellow dot is the average value which is leaning towards left hand side.

E. Curve value

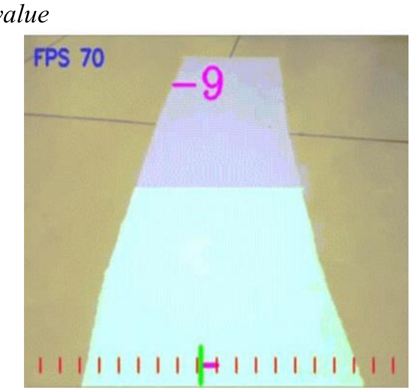

Fig 6. Curve value

At this point, the output will indicate whether to turn left or right.

VIII. CONCLUSION

In summary, a major development in road safety technology is the application of edge devices and image processing for the detection of unsafe road curvature. This system makes use of advanced image processing techniques and edge computing capabilities to detect dangerous road curves in real time and offer drivers with proactive alerts. Based on different factors, the system accurately distinguishes between normal and harmful curves using a combination of standard computer vision techniques and machine learning models. This novel method guarantees minimal latency, scalability, and adaptability, which qualifies it for implementation in a variety of settings. All things considered, the technology advances intelligent transportation systems and is essential to enhancing road safety globally.

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