Lane Detection Algorithm Based on Reliable Lane Markings for Self Driving Vehicles

I B V S Shiva Sai, K Sathish, G Aurava, S Mahboob, K N V C Koushik

Abstract*: *Keeping the vehicle within the lane is an important aspect in the self driving vehicles. These lane lines are detected by using lane detection algorithms. Initially the self driving vehicle captures the footage of the road ahead of it using high resolution cameras mounted on the top of the car. Then the footage is divided into individual frames and the frames are processed further to identify the lane markings. Digital image processing technique is utilized in order to find ROI (Region of Interest) and to eliminate unnecessary noises and glares caused by the reflection of light. Then, the light intensity and width of lane markings are taken as input. An edge detection algorithm is applied to find the boundaries of objects within images. It works by detecting discontinuities in brightness followed by a line detection algorithm is applied on the edge detected image to construct the lines on which the edge point lies. Hough transform with some subsidiary conditions is suitable algorithm preferred. With this proposed model, the lane can be accurately detected in conditions of fluctuating, poor illumination and from interference from reflected light can be avoided effectively. The results obtained demonstrate the accuracy of the proposed method.

Index Terms*: *Self Driving Vehicle, High Resolution Camera, Edge detection, Morphological filters, Hough Transform.

I. INTRODUCTION

Lane detection is a process that is used to locate the lane markers on the road. In [1] the methodology uses speed to frame ratio, here the camera fps(frames per second) needs to be continuously adjusted with respective to the speed of the vehicle. This poses risk factor of the image not being recorded while the camera keeps adjusting fps at higher speeds. But can be utilized in urban areas where the environment around the vehicle changes within fraction of second. [2] focused on alternative to the hough transform to eliminate the limitations in determining the straight line accurately. This resulted in utilizing the line segment detection algorithm which goes well for the straight lane but poses difficulty in estimating the curved lanes accurately. Precise computation is necessary to keep vehicle within the lane. Combining all the sensors data with the reliable software will be helpful in detecting the Region of Interest(ROI) and other important attributes required to identify the lane[3].

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I B V S Shiva Sai, SRM Institute of Science and Technology, Kattankulathur (Tamil Nadu)-603203, India.

K Sathish, SRM Institute of Science and Technology, Kattankulathur (Tamil Nadu)-603203, India.

G Aurava, SRM Institute of Science and Technology, Kattankulathur (Tamil Nadu)-603203, India.

S Mahboob, SRM Institute of Science and Technology, Kattankulathur (Tamil Nadu)-603203, India.

K N V C Koushik, SRM Institute of Science and Technology, Kattankulathur (Tamil Nadu)-603203, India.

LIDAR technology can be used to construct the 3-D scenario of the environment across the vehicle. LIDAR uses pulsated laser to construct the environment. The equipment is highly expensive which prevents it usage commercially [4]. This system decreases the road accidents and also helps to improves traffic conditions. Lane detection consists of specific types of primitives such as road markings etc[5]. Lane detection represents the margins of path into a single framework. It supports various applications like lane departure warning, lane keeping assists, lane centering etc. [6] Lane departure warning gives us a warning when the vehicle is veering off the lane without signaling. Lane detection also plays an important role in advanced driver assistant system [7]. This system helps the drivers in the driving process. This system is developed for safety and better driving. [8] This system based upon vehicle to vehicle or vehicle to infrastructure system etc. Advanced driver assistance system consists of collision avoidance system, blind spot system and many more systems. In lane detection there are many approaches that are applied like feature based and model based [9]. Feature based approach are used to detect edges and model based approach is a type of curve model. The sensing module is an important module in the driverless system. It mainly senses the driving environment during the driving process of the vehicle, and senses vehicles, pedestrians, obstacles and other objects in the surrounding environment of the vehicle and provides the result of the sensing and the path decision module[10]. The corresponding path planning is carried out and finally the mechanical control module realizes the relevant mechanical control operation, so that the car can drive automatically [11]. Lane line detection is an important part of the sensing module. Unmanned driving not only requires obstacle avoidance and road traffic information perception, but also needs to comply with traffic rules. The requirements for lane line detection are relatively high [12]. Many traffic rules are designed so that pedestrians and vehicles must move according to certain rules. In addition to the traffic signal, the reference standard is the road lane line. By detecting the lane line, the ground indicator can be further detected and the front collision warning strategy can be designed.

II. BACKGROUND

Edge detection includes a variety of mathematical methods that aim at identifying points in a digital image at which the image brightness changes sharply or, more formally, has discontinuities.

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The points at which image brightness changes sharply are typically organized into a set of curved line segments termed edges. The same problem of finding discontinuities in one-dimensional signals is known as step detection and the problem of finding signal discontinuities over time is known as change detection. Edge detection is a fundamental tool in image processing, machine vision and computer vision, particularly in the areas of feature detection and feature extraction. The purpose of detecting sharp changes in image brightness is to capture important events and changes in properties of the world. It can be shown that under rather general assumptions for an image formation model, discontinuities in image brightness are likely to correspond to discontinuities in depth, discontinuities in surface orientation, changes in material properties and variations in scene illumination.

In the perfect case, the after effect of applying an edge finder to a picture may prompt a lot of associated bends that demonstrate the limits of items, the limits of surface markings just as bends that relate to discontinuities in surface introduction. Along these lines, applying an edge identification calculation to a picture may altogether decrease the measure of information to be handled and may in this manner shift through data that might be viewed as less applicable, while safeguarding the imperative basic properties of a picture. In the event that the edge recognition step is fruitful, the resulting assignment of deciphering the data substance in the first picture may consequently be generously streamlined. In any case, it isn't constantly conceivable to acquire such perfect edges from genuine pictures of moderate intricacy.

III. ALGORITHM

First the self driving vehicle captures the lane ahead of it in the video format. The video is divided into individual frames for proper analysis and for obtaining accurate results. Gray scaling is applied on every frame separated from the video captured. A ROI (Region of Interest) is indentified for every image. The identified ROI is separated from the original image in order to reduce computational cost and to improve the efficiency of the output. A Gaussian filter is applied to smooth the image by removing unnecessary noises in the image. Canny edge detection technique is applied to find out the edges in the input ROI. After the edges are detected a line detection algorithm is applied to join the edges detected in the edge detection technique. Hough transform is used as line detection algorithm. Once the lane lines are identified the other hardware components of the self driving vehicle can proceed for further steps.

IV. IMPLEMENTATION

Most roads are basically straight, and there are few sharp bends in the curve. Therefore, in the lane detection and tracking, the Hough transform is used to detect the line and determine the approximate position and shape of the lane. Then determine the deviation direction of the lane by the slope of the lane, and then find the curve part of the lane. In this way, the accuracy of the detection of the lane line can be ensured, and there is no serious error in the detected curve. The steps follow as shown in the figure 1 to extract lane markings. At first, the lane is captured by using high resolution camera. The frames are processed to remove the unnecessary glares and to identify the Region of Interest (ROI). Then edge detection algorithm is applied on the image to identify the edges. As the edges detected are not joined properly we use line detection algorithm to join the edges detected. Then edge refining is applied on to the result and it is used as output.

A. Image Preprocessing

As a fore mentioned, the images are from a pair of high resolution cameras. Before they are processed, several pre-process steps are required. First, we design a customized mechanism to determine camera exposure time to prevent over/under exposure. Normally, the exposure time is adjusted based on different metering mechanisms on image overall brightness, e.g. partial area metering, center weighted metering. Here in our approach, the exposure time is calculated based on the road surface (ROI) brightness. The road surface is approximately derived from the previous lane line detection. This is helpful especially when the vehicle moves from a shaded area to an unshaded or the other way round. Secondly, the images from left and right cameras need to be rectified so that the corresponding pixels in the two images lie on the same row. The rectification parameters can be calibrated accurately according to the proposal in. Thirdly, both images need to be converted to grey images. We choose intensity value from HSI color space as the grey value since it has clear advantages than other color spaces (such as RGB).

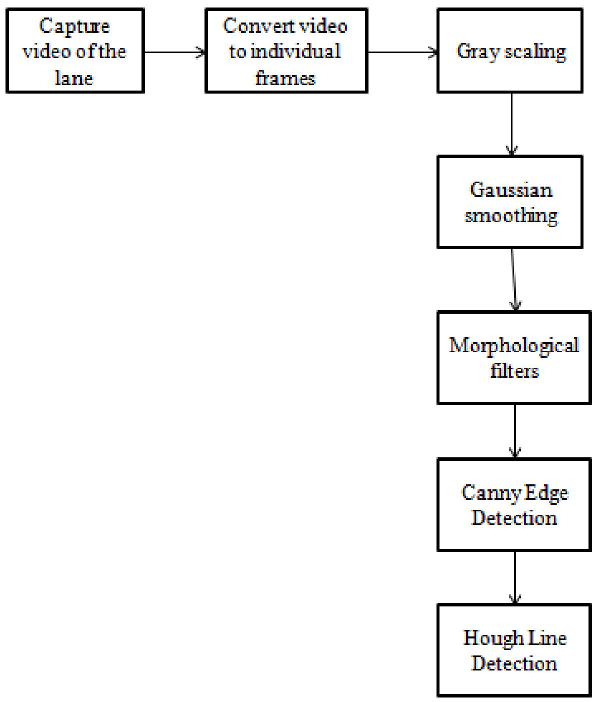

Figure 1. Work Flow representation

B. Intensity based features

Shadows create misleading edges and texture on the road and hence edge features fail to work robustly in presence of shadows. Shadows mask lane-road edges and cause false intensity edges. In different illumination conditions lane markers may have different brightness yet maintain their superiority relationship with their horizontal neighbors.

So, lane markers can be detected by searching for low-high-low pattern horizontally in the image.
Due to point of view bending, hunting down this example is troublesome as path width fluctuates with picture push. We bypass this issue by creating the top-perspective out and about picture. In this reverse point of view picture, the path marker width is consistent. To get the reverse point of view change of the info picture, we accept a level street and process the homography network utilizing the camera inherent (central length and optical focus) and outward (pitch, yaw, and stature over the ground).
The top-see picture is smoothed vertically and tangled with the second subsidiary of Gaussian. We tune standard deviation of the Gaussian to react to brilliant vertical lines of explicit width on a dim foundation. Since the introduction of path marker isn't really vertical, we apply this channel at five introductions (−15◦, −7.5◦, 0◦, 7.5◦, 15◦) and take pixel-wise limit of the channel reaction. The yield of this progression gives an exact estimation of path markers yet regardless we have to limit the channel yield to evacuate boisterous reaction. Our thresholding strategy is like the hysteresis thresholding procedure utilized in Canny edge. We select low and high limit esteems, holding the pixels whose esteem lies over the high edge and those underneath the low edge are rejected. For pixel esteems lying between this range, a diagram seek is performed and the breadth of this chart is registered. Pixels for this diagram are acknowledged whether the measurement surpasses a base limit. This base limit compares to least path marker length experienced in the 10,000 foot picture. This limit is set considering the dashed paths looked in different situations.

C. Morphological Filters

Binary images may contain various blemishes. Specifically, the paired locales delivered by basic thresholding are mutilated by clamor and surface. Morphological picture handling seeks after the objectives of expelling these blemishes by representing the structure and structure of the picture. These strategies can be stretched out to grayscale pictures. Morphological picture handling is an accumulation of non-straight tasks identified with the shape or morphology of highlights in a picture. Morphological tasks depend just on the general requesting of pixel esteems, not on their numerical qualities, and hence are particularly fit to the handling of twofold pictures. Morphological activities can moreover be associated with grayscale pictures with the true objective that their light trade limits are dark and as needs be their by and large pixel regards are of no or minor interest. Morphological strategies test a picture with a little shape or format called an organizing component. The sorting out part is arranged at all possible regions in the image and it is differentiated and the relating neighborhood of pixels. A couple of exercises test whether the segment fits inside the territory, while others test whether it hits or crosses the region.
A morphological activity on a twofold picture makes another double picture in which the pixel has a non-zero esteem just if the test is fruitful at that area in the info picture. The organizing component is a little parallel picture, for example a little network of pixels, each with an estimation of zero or one. The framework measurements determine the extent of the organizing component. The example of zeros determines the state of the organizing component. A starting point of the organizing component is typically one of its pixels, albeit for the most part the source can be outside the organizing component. element is positioned at all possible locations in the image and it is compared with the corresponding neighborhood of pixels. Some operations test whether the element fits within the neighborhood, while others test whether it hits or intersects the neighborhood.

D. Edge Detection

Canny edge recognition is a procedure to remove helpful basic data from various vision objects and significantly decrease the measure of information to be handled. It has been broadly connected in different PC vision frameworks. Watchful has discovered that the necessities for the utilization of edge identification on differing vision frameworks are moderately comparable. In this manner, edge recognition answer for location these necessities can be actualized in a wide scope of circumstances. The general criteria for edge identification incorporate location of edge with low mistake rate, which implies that the discovery ought to precisely get whatever number edges appeared in the picture as could be allowed. The edge point identified from the administrator ought to precisely confine on the focal point of the edge. Guaranteed edge in the picture should just be checked once, and where conceivable, picture commotion ought not make false edges.
To fulfill these prerequisites Canny utilized the analytics of varieties a strategy which finds the capacity which enhances a given utilitarian. The ideal capacity in Canny's locator is depicted by the total of four exponential terms, yet it tends to be approximated by the main subordinate of a Gaussian. Among the edge identification techniques grew up until this point, Canny edge location calculation is a standout amongst the most carefully characterized strategies that gives great and solid recognition. Attributable to its optimality to meet with the three criteria for edge location and the effortlessness of procedure for usage, it wound up a standout amongst the most prevalent calculations for edge recognition.
The process of Canny iedge detection algorithm can be explained five different steps:

1. Apply Gaussian filter to smooth the image in order to remove the noise.
2. Find the intensity gradients of the image.
3. Apply non-maximum suppression to get rid of spurious response to edge detection.
4. Apply double threshold to determine potential edges.
5. Track edge by hysteresis: Finalize the detection of edges by suppressing all the other edges that are weak and not connected to strong edges.

After utilization of non-greatest concealment, remaining edge pixels give a progressively exact portrayal of genuine edges in a picture. Be that as it may, some edges pixels remain that are brought about by commotion and shading variety. So as to represent these false reactions, it is fundamental to sift through edge pixels with powerless angle esteem and protect edge pixels with high slope esteem. This is cultivated by choosing high and low limit esteems. If an edge pixel's point regard is higher than the high
edge regard,

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it is separate as a strong edge pixel. In case an edge pixel's slant regard is humbler than the high edge regard and greater than the low edge regard, it is separate as a delicate edge pixel. In case an edge pixel's regard is tinier than as far as possible regard, it will be covered. The two edge esteems are observationally decided and their definition will rely upon the substance of a given info picture.

E. Extracting lane line

The Hough transform is a component extraction method [8] that distinguishes objects with a particular shape, normally straight lines, circles, and ovals. The rule is to suggest the first space into the parameter space and vote in the parameter space to get the ideal chart. The path line recognition in this paper depends on the factual presentation Hough line detection. The standard is the change from focuses to bend, in which the essential advance is to change over the Cartesian facilitate arrangement of the picture to the polar organize Hough space. Also, the outcome is the change from every pixel facilitate P(x, y) in focuses to (ρ,θ) over the average performer focuses.

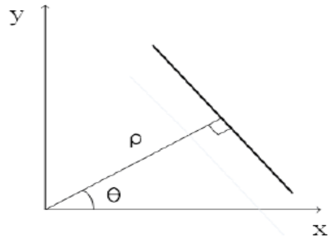

Figure 2. Hough Transform

Since the path line is anything but difficult to be lost amid location, so as to guarantee the precision of the discovery impact, this article utilizes following innovation to improve the identification speed and exactness. The essential thought of the following is that the vehicle is a persistent removal development process amid the progression of the vehicle. The difference in the path line is additionally a ceaseless change. This change is reflected in the slant of the path line. The incline of the path line in the two casings of the front and back pictures are very little not quite the same as the situation of the path line. Along these lines, the two edges when the control are looked at. The slant of the path line in the center is restricted close to the recently distinguished path line zone. This is the essential thought of following. Discovering path lines inside the region of intrigue can incredibly lessen the measure of picture preparing.

For the circumstance that the path lines of the street in the picture are commonly disseminated on the left and right sides of the street, the use of the conventional Hough change is improved in this paper to constrain the extent of its casting a ballot space, that is, to characterize ρ and θ to alter the extent of its casting a ballot space. The polar point and the polar measurement of the left and right path lines are constrained, and the camera is balanced. Through nonstop testing, the polar edge limitation zone and the polar distance across imperative territory of the objective point are gotten, and the locale of intrigue (ROI) is acquired, and just paths in the white region are recognized. By setting up the polar edge and the polar width requirement zone, countless focuses can be adequately expelled, the impedance of the roadside tree structures can be sifted through, and the running pace of the calculation can be incredibly improved. At the point when the polar edge of the path line is inside the recognition zone, the situation of the path line can be rapidly and precisely distinguished. Notwithstanding, when the picture is moved in a turn, path change or camera position, the path line effectively surpasses the discovery region, with the goal that the outcomes seem a few deviations.

For the conventional Hough transform, each direct needs toward be navigated at each edge, which is tedious. In this paper, the changed Hough transform is utilized to perform Hough transform on the evaporating point and the restricted pixels around it. The two pinnacle purposes of the left and right path lines are acquired and the path lines are drawn. This strategy can adequately smother other edge clamors of the picture and improve the continuous execution of the calculation.

Following is separated into disappearing point following and path line following. (1) Vanishing point following: disappearing focuses are commonly far away, and the evaporating point scope of vehicles isn't changed especially amid the advancement of the vehicle. On the two sides of the street close to the path line, the contact of the vehicle tires is visit and the surface is increasingly self-evident. The commitment to the evaporating point is Larger. Along these lines, arbitrarily select 100 sets of focuses close to the evaporating point line and a few points around it to cast a ballot. (2) Lane line following: According to the consequences of the past casing estimation, the restricted point is inside a specific scope of variety, Hough transform is performed, which incredibly lessens the task speed. At the point when the quantity of evaporating focuses and path lines of the picture location is not exactly the upper purpose of the set edge, the program is reinitialized.

V. RESULTS

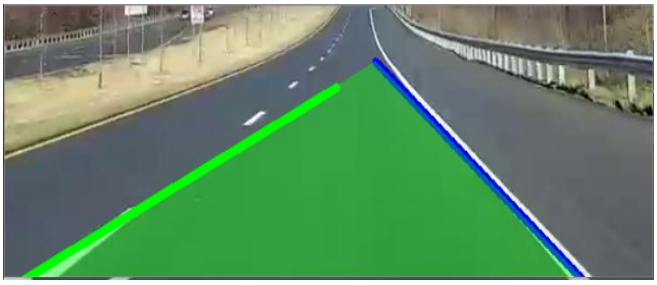

Figure 3 Output After Hough Line Detection

The implementation is carried out in Open CV platform using python language. Open CV is preferred for its support for wide range of libraries needed for the implementation. From the results obtained the lane detection is accurate when the footage is taken in proper illumination conditions. But failed to detect in rain and fog conditions where the image quality is poor.

VI. CONCLUSION AND FUTURE WORK

However the proposed system can analyze the environment around the vehicle in 2-D (by analyzing image). In future we are going to construct the environment around the vehicle using LIDAR technology. LIDAR stands for Light Detection and Ranging, uses high laser beam to construct the 3-D environment.

The data gathered by LIDAR can be collected and can be used for feeding into deep learning algorithms. By exposing the vehicle to different kind of scenarios in real life the vehicle can use its previous knowledge and can act according to the situation. Further as the cost of LIDAR equipment drops, it can be used in commercial vehicles.

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