Recent Advancements in Lane Detection: A Review

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Abstract: ***As of late greatest research is performed on lane detection and lane departure system. The thought process behind the research is the wellbeing of the vehicle drivers and travelers out and about and diminishes the mishaps. Driver Assistant System's (DAS) main task is to detect the road.There are two kinds of road regions: organized/structured and unstructured road regions. In the urban territory, we discovered structured regions with appropriate lane marking and boundaries appropriate limit stamping and path checking. In rustic zones, we discovered unstructured road regions without appropriate boundaries and lane markings. Recognizing the unstructured street area is a testing issue. This paper describes the various lane detection techniques as well as the performance of various lane detection algorithms is studied and compared.***

***Index Terms*: lane detection, road region, lane marking, lane departure system, structured roads, and unstructured roads.**

I. INTRODUCTION

Vision-based lane identification is an area where researchers are doing research for the people's safety on road. The main intention behind it is to avoid road accidents which took place every year. As per a survey conducted in India in 2016, it has been observed that there are 17 deaths on road per hour due to vehicle collision and while departing the lane. If we see the count of the people who died in road accidents in 2014 is 1, 39,671 [20]. We can avoid these accidents by implementing the lane departure warning system in vehicles. The main causes of accidents are speed of the vehicle, hasty driving at the time of changing the lane.

Having a lane departure system as well as detecting the curves of the road is essential [21]. Be that as it may, the main issue in building the system is distinguishing the road and path acknowledgment and recognizing hindrance, for instance, vehicles and human being on the pathway. Advanced Driver Assistance System (ADAS) alerts driver in hazardous conditions or takes an active part in the driving and is merged into the vehicles. These type of systems are depended upon to grow progressively complex towards full self-lead in the midst of the next decade. The standard bottleneck in change of such systems is the acumen problem [22], which has two segments: i) road and way/lane acknowledgment ii) obstacle (i.e. vehicles and bystander) detection.

Detecting road regions is a key feature of Driver Assistant System. Lane departure warning system is a part of the driver assistant system. Road regions are of two types: structured and unstructured. Structured road regions have appropriate lane marking and boundaries whereas unstructured road regions do not have appropriate lane marking and boundaries. Detecting the unstructured road regions has following challenges [22][23][24][25].

1. On some roads, faded lines are there which affects the quality of lines which is bad for processing.
2. Shadows of trees and building on the road, structures of the road and different vehicles.
3. Sharper curves on the road
4. The soiled road and the area around have the same colors.
5. varying illumination conditions,
6. Different viewpoints
7. Natural condition issues which influence on the picture lucidity like streets secured with the snow, mist, overwhelming downpours, and reflection on wet street low perceivability.
8. Arbitrary road shape which leads to a road surface with a degraded appearance

Fig 1. Lane detection challenges [25]

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Fig. 2 shows some glimpses of different lighting, weather conditions, and viewpoints.

Isolating the lane markings from the foundation mess and detecting their definite position by using the special hardware or by using machine vision-based algorithms is the key aim of the lane detection. The lane detection algorithm ought to be equipped for adjusting to the regular open-air environment, incorporating irregularities in lighting, foundation mess and lane impediment. As per [27] [3], for detecting the lane two types of methodologies are utilized and they are: i) feature-based strategies ii) model-based techniques.

Feature based method

The feature-based method is used for boundary detection from the road images by isolating low level features. Feature-based strategies need a dataset containing only a few thousand pictures of streets with very much painted and noticeable lane markings which are thusly changed over to features. Feature-based techniques are hard to actualize as they need a little earlier known geometric parameters and substantial calculation. This technique analyzes pictures and recognizes the inclinations of pixel data or the shade of examples to distinguish the lane markings. In addition, these techniques could experience the ill effects of clamor [17].

Model-based Method

This method uses a few geometrical components to depict the lanes, including straight lines, parabolic curves, and hyperbola. It is progressively incredible against commotion.

This paper displays the writing review of the last 3 to 4 years of advancement in lane detection and departure system.

Section II reviews the last 3 to 4 years paper and gives an idea about the methods used for lane detection and advantages and disadvantages of the methods in a table form. Section III concludes the paper.

II. LITERATURE SURVEY

Umar Ozgunalp et al. [12] introduced a novel path detection algorithm for recognizing different paths from the example picture. The system permits the multiple detections of the path streets despite the fact that the traffic was viewed as thick and high. The authors have physically set up the vehicle utilizing air-suction cushions and therefore had minimal changes in the moving edge of the camera.

Apurba Das et al. [13] worked on the binarization method by altering the min-between-max thresholding (MBMT) approach and subsequently named as MMBMT. The detection consequences of the proposed MMBMT were viewed as prominent with the worldwide MBMT. Here, the ground truth is considered as the baseline casing, and in this manner, the minimal blunder can actuate an uncommon change in execution, and consequently, the system requires manual detection. The lane markings identified are seen to be impressively conspicuous as for classical global MBMT.

Soonhong Jung et al. [14] developed the path detection display dependent on spatiotemporal pictures. The method executed undertakings like as binarization and scaling dependent on the dominant parallel lines for path detection. The real favorable position of the system was that it required just less computational time in contrast with different strategies. The detection rate is somewhat made strides.

Ju Han Yoo et al. [15] built up the strong path detection strategy utilizing the vanishing point estimation model. Utilizing the vanishing point conspire enhanced the detection rate in an alternate situation. The competitor line sections extricated for the detection procedure can contrast from the beginning while at the same time executing the equivalent in 3D space.

Xinxin Du and Kok Kiong Tan [16] built up the viable stereo 3D reproduction strategy for path detection, and the model detected the path with the assistance of the remaking approach. The system was appropriate for the mechanized vehicle system attributable to its high precision. Additionally, the system can be considered as the enhancement to the vehicle path level confinement. The proposed system can think of some as street highlights like the path markings bringing about false detection.

Jianwei et al. [17] developed a Two-Stage Feature Extraction (LDTFE) lane detection approach. The LDTFE demonstrate can acclimate to the troublesome situations like as little line sections and line ebbs and flows. In specific cases, the street may have nonexistent lines prompting path detection disappointment.

Heba Aly et al. [18] displayed a novel path detection demonstrate regularly alluded to as Lane Quest. The proposed LanQuest plot recognized the street paths utilizing the cell phone, and furthermore, the system was vitality proficient. Utilizing wrong cameras alongside the cell phones had expanded the likelihood of path detection in outrageous climate conditions.

Son Lam Phung [19] proposed the vision-based method for supporting the pedestrian in the path detection. The proposed system had less mind-boggling structure and subsequently has high vigor and exactness. The model neglected to perceive the street paths in solid shadow conditions.

Jihun Kim et al. [1] developed Extreme learning

convolutional neural system for lane detection and proved its feasibility. For the clear road scenario RANSAC algorithms is used and for the complex road scenarios AI based or machine learning techniques were applied.

The ELM is a brisk learning strategy used to assess organize loads among yield and shrouded layers inside a solitary cycle and thus, can definitely reduces learning time while making exact result by insignificant preparing information. Here, ELM has appeared differently in relation to customary CNN. Stacked ELM building in the CNN framework is proposed in this paper and back propagation algorithm is modified for finding the shrouded layers and reasonably learns network weights while looking after execution.

Li et al [2] introduces deep neural network system to accommodate the structures for visual examination. Two new types of profound neural systems Convolutional Neural Network (CNN) and Recurrent Neuron Network (RNN) are made for lane detection in rush hour gridlock scenes. A multi-task deep convolutional neural network is built for sharing features learning between multiple prediction tasks. Plus, a recurrent neuron layer has been gotten over the convolution feature extraction. The repetitive neurons fill in as memory cells for the system and engage the system to learn structures in a succession of predictions. In light of the recurrent neural network, a lane boundary marker is structured to work with or without bigger addition models of traffic lanes. First CNN at the same time distinguishes the proximity of the goal and the geometric traits (territory and direction) of the goal with respect to the region of interest. Next, a recurring neuron layer is embraced for structured image detection. The recurring neurons can manage the spatial appropriation of noticeable signals having a place with an object whose outline or formation is difficult to depict unequivocally. The two systems are appeared by the realistic errand of identifying lane boundaries in rush hour gridlock scenes. The multi-task CNN gives valuable geometric data to help the resulting displaying of given way structures. The RNN distinguishes lane boundaries, and includes those regions containing no engravings, with no unequivocal prior data or optional modeling.

Chanho Lee [3] has proposed vision based lane detection and lane tracking algorithm with ROI. Introduction of the lane detection and tracking is given in the algorithm. The ROI is a curved trapezoidal region enveloping the lane markings and it is located by using the vanishing point (VP). The lane markings in the ROI are detected and tracked. A gradient cue and color cue is formed together and a grouping of line is done with the scan line test for checking the traits of the lane markings.

Jung et al. [4] built up a lane detection algorithm reliant on spatiotemporal pictures. Here, a balanced spatiotemporal image is created by collecting the pixels on the scan line along the time axis and by altering the progressive scan lines. Lane point's direction appears smooth and it forms a straight line. The balanced spatiotemporal image is then binarized. Hough transform is utilized to identify the 2 predominant similar straight lines coming about as a result of the common uniformity of lane width on a given scan line by diminishing course of action mistakes. The right and left lane points are then recognized close for intersection purposes of the straight lines and the present scan line. The Spatiotemporal zone approach is fierier absent or blocked lanes than existing edge based techniques.

Chung-Bin Wu et al.[5] has developed a system for lane detection and lane departure warning system, the system uses an ultra-low complexity block. Here, a parameterize Region of Interest (ROI) near vehicle is determined. To recognize the lane markings in different conditions, an intensity of the pixels on the lane markings in ROI is increased. ROI then divided into non-overlapping blocks which reduces the computational burden. For getting the block gradients and block angles two disentangled masks are proposed.

Yingna Su et al.[6] developed a strong vanishing-point lane detection strategy with a stereo- rig. This procedure doesn't expect parametric lane appear for lane detection. Street vanishing point detection relies upon v-d; d means divergence and v means visual odometry frameworks. The searching space for vanishing point is reduced by the v- disparity map. The straight and curve street's detection is done with the help of the visual odometry. To get the minimum cost map Dijkstra's shortest-path lane model is utilized. The two-lane fringes are distinguished by finding two ideal paths.

Kodi et al.[7] developed a modified lane detection algorithm for detecting the lane curvature. An autonomous vehicle plays a critical role in this. For deep learning, a ground truth marking toolbox is utilized for recognizing the bent way in the autonomous vehicle.

Liang Xiao et al. [8] developed created a conditional random field (CRF) for combining the data from camera and LIDAR. Here, the first pixels are lined up with the LIDAR, labels and the LIDAR points are measured as random variables. Labels are gathered by performing minimization of a hybrid energy function. The edges include the associations between the adjacent pixels in picture plane between adjacent LIDAR points in the 3D space and between attuned LIDAR points and their contrasting pixels. The data is coordinated probabilistically from two sensors in this model. It uses the two sensors very efficiently. The half and half CRF model can be upgraded productively with diagram slices to get street areas. The unary possibilities of the pixels and LIDAR focus are altogether gotten by offline learned boosted decision tree classifiers. Pairwise possibilities promise relevant uniformity in pictures and point mists, and also cross-modular uniformity between the attuned pixels plus LIDAR points.

Yueyue Na et al. [9] proposed an acoustic lane detection technique for the multi-lane traffic monitoring framework. Lane detection is the initial phase in multi-lane traffic monitoring. This strategy consequently recognizes lane positions and widths from the vehicle radiating sounds. In the microphone, as per the Chinese highway configuration an array is designed. The plan depends on the cross-array formation. The cross-correlation matrix from the two sub-arrays in the chosen working frequency band is calculated for the resulting traffic monitoring operations. Then, across the road a cross segment is developed by beam forming. Here, single-source assumption can be connected, and the passing vehicle azimuth is recognized by the anticipated rank-1 Multiple Signal Classification (MUSIC) algorithm.

lastly, a Parzen-window-based procedure is introduced to evaluate the vehicle azimuth

Probability Density Function (PDF) from the individual azimuth perceptions. Lane midpoint and boundary is discovered from the peak and valley patterns of assessed PDF.

Bok-Suk Shin et al.[10] utilizes a particle filter to recognize the left and right lane borders independently. It utilizes two particle filter one for left border and second for right border. Different particles are connected to recognize appealing particle in one picture row, into one superparticle, and by utilizing local linear regression for altering detected border points.

Kortli et al. [11] utilized a Hough Transform for lane and vanishing point detection. Vanishing point detection was utilized to get the region of interest (ROI) that will lessen the unpredictability of the algorithm for the following casing. The Otsu's threshold was actualized to conquer the brightening variation issue. The Hough Transform extricates the lane limits and screens the vehicle's situation as for the lane and gives a notice if the vehicle is going to leave the lane. Pre-processing step connected for smoothing and gradient detection of the picture. After an RGB to grayscale picture conversion, we apply a Gaussian filter to smooth picture gradient. Subsequent stage, we pick a Sobel operator on the smoothing picture for edge detection. Otsu's threshold strategy is connected to manage a lighting issue. Hough Transform is connected with the end goal to distinguish a vanishing guide serves to decide the ROI which lessens the computational unpredictability for next casing. Finally, the framework decides whether the vehicle floats of the correct lane or not, contingent upon the vehicle position.

Authors	Method	Advantage	Disadvantages
Jihun Kim et al.[1]	Extreme Learning convolution neural network (ELM)	Diminishes training time contrasted with traditional CNN's. Appropriateness to continuous applications is fundamentally expanded. ELM learning guarantees a worldwide most extreme given the objective yield; got better precision than that of the ordinary CNN on a few unique databases. Improved performance as compare to CNN	ELM needs the matrix inversion for increasing the computational time dramatically for high-dimensional data. Do not reduce local minima problem
Li et al2]	Convolutional Neural Network (CNN) and Recurrent Neural Network. (RNN)	In practical traffic scenes, the lanes are detected effectively using the CNN and the RNN detectors.	RNN results are not better than SVM
Chanho Lee[3]	vision-based real time lane detection and tracking algorithm with an efficient region of interest(ROI)	Decrease high commotion level and figuring time. It expels any bogus lane markings as well as tracks. The genuine lane markings utilizing the gathered factual data.	It is difficult to identify the lane markings when roads are covered with the snow and when roads are not visible because of the reflected road lights in blustery evenings.
Jung *et al.* [4]	Spatiotemporal images for detecting the road lanes.	smother boisterous lane points close to the lane markings	. Detection fails when number of uproarious lane points surpasses a specific threshold. It gives error if the width of the lane increases or decreases and while finding the vertical line. A speed of the vehicle affects the spatiotemporal image, which will influence the detection results
Chung-Bin Wu et al.[5]	**ultra-low complexity block**	Reduced computational complexity. Lanes are detected efficiently.	The results are still not more than other algorithms.

Yingna Su et al.[6]	**vanishing-point(VP), stereo-rig**	**On the variety of road scenes it works accurately and robustly.**	The performance will degrade if training images and different from testing
Kodi et al[7]	Detecting curvature of the lane using customized lane detection algorithm.	80% to 90% efficiency and accuracy is achieved.	Only useful for curve detection.
Liang Xiao et al.[8]	hybrid conditional random field CRF model	reduces the ambiguities in road detection	Sensors are expensive.
Yueyue Na et al.[9]	**Lane detection based on acoustic**	The acoustic-based feature is vigorous against light and climate variations. acoustic sensor (microphone) is relatively inexpensive than other traffic monitoring sensors like camera and radar	It still not robust to climate conditions like fog.
Bok-Suk Shin et al.[10]	particle filters	Robust for border detection	
Yassin Kortli et al [11]	Hough Transform	Reduces the computational complexity. works accurately in various lighting conditions	There are problems with blur lane marks as well as with uneven road surface.
Umar Ozgunalp *et al.* [12]	A novel lane detection algorithm	It detects multiple lanes with vertical and horizontal curvature. In dense traffic, it works robustly and accurately. computation time reduced to as little as one-third as compared to other methods	The experimental set-up is installed manually onto the vehicle utilizing air-suction cushions and a lot of roll angle is needed to be acquainted due with this underlying establishment. In spite of the fact that the roll angle **doesn't** modify fundamentally after some time, roll angle presented amid camera establishment onto the vehicle should be assessed as a piece of calibration process.
Apurba Das *et al.* [13]	Binarization algorithm using Min-Between-Max Thresholding (MBMT).	The lane markings recognized are seen to be fundamentally conspicuous concerning classical global MBMT	Ground truth framework is used, a baseline frame is considered as the reference at the time of Validation, a little blunder would not be acceptable. Thus, the algorithm ought to likewise coordinate the client with casings where manual intercession is required.
Soonhong Jung *et al.* [14]	Spatiotemporal images for detecting road lanes	As compared to other methods the computation time is reduced to as little as one-third.	Slight improvement rate of detection is noticed.
Ju Han Yoo *et al.* [15]	vanishing point estimation	Vanishing point is estimated efficiently as well as the lines are detected in different environments.	The chosen candidate line segments includes the line segments which is taken out from the neighboring environment and are not parallel to lanes in the 3D space.

Xinxin Du, and Kok Kiong Tan [16]	effective the stereo 3D reconstruction method	This system is implemented in the autonomous driving vehicle because of its high accuracy and consistency. It is a practical solution to vehicle lane-level localization.	In any case, other than lane line markings, bumps, zebra intersections, cautioning letters and bolts likewise display comparable highlights and might be false distinguished as lane line markings
Jianwei Niu *et al.* [17]	Two-stage Feature Extraction (LDTFE)	The small line segments located on the straight line or a line which has a small curvature are detected.	As there are many non-consistent collinear edge pixels present it results in missing line. For such situation, detection of small lanes turns out to be very unlikely.
Heba Aly *et al.* [18]	LaneQuest	LaneQuest has a low energy footprint that permits LaneQuest to be implemented on the energy-constrained portable devices.	Cameras are liable to errors because of the various things like lighting condition, bad climate and the additional environmental noise. In addition, the high energy is needed by the cameras for the restricted phone battery
Son Lam Phung [19]	vision based algorithm	Highly capable as well as robust as compared with several existing methods.	There are some segmentation errors, where there is a strong shadow

III CONCLUSION

In this paper, we have reviewed the recent 3 to 4 years of methods for lane detection and tracking. As we have seen there are two techniques used for lane detection, model-based technique and feature-based technique. As compare to feature based techniques the model based techniques are more vigorous against noise. On the other hand feature- based techniques may suffer from noise. It has been observed that Convolutional Neural Network (CNN) and deep neural networks are outperforming in lane detection. Hough Transform is still used to reduce the computational complexity. Vanishing point methods are also efficiently calculating the vanishing point.

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