NOVATEUR PUBLICATIONS
INTERNATIONAL JOURNAL OF INNOVATIONS IN ENGINEERING RESEARCH AND TECHNOLOGY [IJIERT]
ISSN: 2394-3696
VOLUME 3, ISSUE 5, May.-2016

A REVIEW ON LANE DETECTION AND TRACKING TECHNIQUES

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ABSTRACT:
Most of the people die every year in road crashes due to driver's inattention and not following the traffic rules. The Lane detection systems are useful to avoid the accidents and safety is the main purpose of the system. The main goal of these systems is to detect the lane stripes and to warn the driver in case of the vehicle tend to depart from the lane. Many intelligent vehicles transport systems have the lane detection system as an important element while driving. Therefore, Lane detection and tracking is the challenging task in computer vision. In this paper, the different vision based lane detection techniques and algorithms are discussed. The performance of the different lane detection technique is also compared and studied.

INDEX TERMS: Advance Driver Assistance System (ADAS), Hough Transform (HT), Lane detection, Lane Tracking, Lane departure warning.

I. INTRODUCTION:
Now a day's the road accidents have increased to a great extent. Most of the accidents occur due to driver's negligence and carelessness while driving. Advance driver assistance system (ADAS) plays an important role in providing safety to drivers. It helps to automate the car system and increases the driving experiences. The Advance driver assistance system provides a safe system to reduce the road accidents. The system takes an active step like warning the driver or takes a corrective action to avoid an accident during the dangerous situation. The Lane Departure Warning (LDW) is an important module in Advance driver assistance system.

In vision based lane departure system, a camera is placed is placed behind the wind shield of the vehicles and images of the road is captured. The white stripes on the road are interpreted and lanes are identified. Whenever the vehicle goes out of the lane then the warning is given to the driver. In lane departure warning system, the lane detection is the initial step to be taken. There are two classes of approaches used in lane detection: the feature based approach and the model based approach. The features based approach detects the lane in the road images by detecting the low level features such as lane edges or painted lanes etc. This approach requires well painted lines or strong lane edges, otherwise it will fail. This approach may suffer from occlusion or noise. The model based approach use geometric parameters such as assuming the shape of lane can be presented by straight line or curve. This approach is robust against noise and missing data. [1][3]

II. LANE DETECTION AND TRACKING ALGORITHMS:

In this section the various tracking algorithm for lane detection is discussed. The Table below summarizes and presents the various lane detection and tracking algorithms.

Y. Wang, E. K. Teoh and D. Shen [1] introduced "lane detection and tracking using b-snake". Here lane detection and tracking is proposed without using any cameras parameters. B-Spline can form any arbitrary shape by a set of control points so the B-Snake based lane model is able to describe a wider range of lane structures. By using the knowledge of the perspective parallel lines the problems of detecting both sides of lane markings (or boundaries) have been merged here as the problem of detecting the midline of the lane. For providing a good initial position for the B-Snake, a robust algorithm called CHEVP is pro-posed. Also to determine the control points of the B-Snake model, a minimum error method by Minimum Mean Square Error (MMSE) is proposed by the overall image forces on two sides of lane. This method is robust against noise, shadows, and illumination variations in the captured road images. It is applicable to the dash and the solid paint line roads also to the marked and the unmarked roads.

M. Aly [2] introduced "A Real time detection of lane markers in urban streets". It is a real time, efficient and robust algorithm in urban streets for detecting lanes. The top view of the road images is generated using the inverse perspective mapping to reduce the perspective effect. Selective Gaussian kernel is used to filter the top view of the road image .Then RANSAC fitting technique is used to detect the lanes. This technique gives good result in all-weather condition but still there are some false positives. The drawback of these techniques is that it does not gives well accurate results for lane detection.

C. Mu and X. Ma [3] introduced "Lane detection based on object segmentation and piecewise fitting". The image captured by the camera is then converted to grey scale using piecewise linear transformation method. The region of interest (ROI) is obtained by the OTSU segmentation method. Then the sobel edges detection is used to detect the lane in the road images. This technique is robust in the presence of noise, shadow, lack of lane painting and changes of illumination conditions.

Parajuli, M. Celenk and H. Riley [4] introduced "Robust lane detection in shadows and low illumination conditions using local gradient features". Here individual frame is extracted from the video and process each frame to detect and track road lane stripes.
Then using vertical gradient of the image the shadow along the road is removed. This technique can locate precise lane marking points on each horizontal and curve stripes. The disadvantage of this technique is that it cannot detect the any high dynamic range portion of the image.

Y.Li, A.Iqbal, and N.R.Gans [5] introduced "Multiple lane boundary detection using a combination of low-level image features". To detect the edges in ROI, Canny edge detector is used. The straight lines are detected from the binary output of Canny edge extractor using

Hough transform. To eliminate effect of noise local maxima features are searched along the estimated lane boundary. Then RANSAC algorithm is applied to eliminate outliers. The final local maxima features are fit into a straight line. Next Kalman filter is used to track the lanes in remaining frames.

J.Wang, T.Mei, B. Kong, and H.Wei [6] introduced "An approach of lane detection based on Inverse Perspective Mapping". Here uses an overall optimal threshold converting the input image to binary. Inverse perspective mapping is done to avoid the perspective effect. Then K means clustering is performed to partition n samples to k clusters. Considering all the points in a cluster as control points, B-spline fitting is implemented to obtain lane marker.

S. Srivastava, M. Lumb, and R. Singal [7], "Improved lane detection using hybrid median filter and modified Hough transform". The main objective is to integrate lane detection algorithm with improved Hough transform and HMF to improve the results when noise is present in the signal. The main objective is to integrate lane detection algorithm with improved Hough transform and HMF to improve the results when noise is present in the signal. The method developed is working efficiently and gives good results in case when noise is not present in the images.

Bing Yu, Weigong Zhang, and Yingfeng Cai [8] introduced "A lane departure warning system based on machine vision". Firstly the Gaussian filter is used to remove the small noise in the road images. Then the dynamic threshold Value is judged by histogram statistics. And the linear parabolic model fitting is conducted to detect the lane from the road images. The lane departure decision is made on the basis of an angle between lanes and the horizontal axis. In this algorithm less parameters
are needed to detect the lane departure compared to TLC or CCP.

Qing lin, Y. Han and H. Hahn [9] introduced "Real time lane detection based on extended edge linking algorithm". This method is based on Region of interest (ROI). First the region of interest is determined and then sobel operator along with non-local maximum suppression is used to find the edges pixels. After detection of edges, then extended edges linking based on direction edges closing is done. The raster scan is performed to find out the starting point of edge. Then edges tracing is carried out and adding the pixels along the orientation to fill the gaps. The edges with length less than 15 pixels are removed out. Next step is to detect the color of the lane markers using lane hypothesis verification. After that Hough transform is applied to determine the values of θ and ρ.

V. Bottazzi et. al. [10] introduced "Adaptive region of interest based on HSV histogram for lane marks detection". The lane detection method is based on the histogram. Using a prior triangle model a dynamic region of interest is determined. First step is to calculate the histogram of the whole image and the road frame. The illumination changes are found out using the difference between the two images. The lane markers are segmented from the ROI. Lucas Kanade tracking is used to track the lanes.

C. Guo [11] introduced "lane detection and tracking in challenging environments based on a weighted graph and integrated cues".
First the input image is converted to inverse perspective image and then multiscale lane detection is done on images. Normalized cross correlation is used to find out the similarity of corresponding pixels. Learning algorithm is used to find out whether the lane marking is painted or not. Then weighted graph is constructed by integrating the intensity and the geometry cues.
The weighted graph corresponds to pixels of a lane point. Using particle filter the lane boundary is determined. This algorithm is suitable for curve lanes, splitting and merging lanes.

Y.C. Leng and C. L. Chen [12] introduced "vision base lane departure detection system in urban traffic scenes". The Sobel operator is used to detect the edges. Then Hough transform is used to detect he straight lanes. Lanes sometimes appear to intersect in road images. Then width of the lane differs at the different height of the images. The width lane is between the minimum and the maximum values. The left and right lane boundaries width is determined based on the width of the lane. Then the lane departure can be determined by position of the lane boundary.

H. Jung et. al. [13] introduced "An Efficient lane detection algorithm for lane departure detection". Here the image is partitioned into two rectangular regions. The lane markers appearing diagonal are detected using diagonally directional steerable filter.
Then the left and right lanes are computed. The lane converges at the vanishing point as they in parallel. Then hypothesis is verified of the detected lanes. By determining the distance between the vanishing point and the horizontal line, the lane departure can be determined.

S. Zhou et. al [14] introduced " A novel lane detection based on geometrical model and Gabor filter". This algorithm contains three modules: lane model generation, parameter estimation and matching. The lane model contains the three parameters: lane width, original orientation, lane curvature and the middle line. Finally the lane model is obtained using the lane width. Vanishing point is detected using Gabor texture analysis, to estimate the lane parameters. Then Gaussian model is used to obtain the single vanishing point. The width and the orientation of the lane are estimated after vanishing point is detected. Then the canny edges detector and Hough transform is used to detect the lane boundaries. At last matching algorithm is used to detect the curvature of the road.

H. Tan et. al. [15] introduced "A novel curve lane detection based on improved river flow and RANSAC". First, Inverse perspective mapping is done on the input image. Then the ROI is divided into two regions: near vision field and far vision field. Straight lines are detected using Hough transform from the near vision field. Then improved river flow is method is used in far vision field to extend the point detected in near vision field. The RANSAC algorithm is used to model the detected feature points in hyperbola pair model.

V. Gaikwad and S. Lokhande [16] introduced "lane departure identification for advance driver assistance". The image captured by the camera is first processed using piecewise linear stretching function. It increases the contrast level of the lane image. The OTSU method is used to select the threshold values. Then 40% ROI is segmented and partition into two parts. The lane identification and tracking is done using the Hough transform. Then the lane departure is determined using the Euclidean distance. This algorithm proves good in detecting straight and curve roads.

Table I: Comparison of Various Lane Detection and Tracking Algorithms

METHODS	PREPROCESSING	DETECTION	TRACKING	ADVANTAGES	DRAWBACKS
Y. Wang et. al. [1]		Canny/Hough Estimation of vanishing points		This algorithm is proposed without using camera parameters	The problem of detecting the mid line of the lane
M. Aly [2]	Inverse perspective mapping, Selective oriented Gaussian filters	Hough transform and RANSAC spline fitting		Comparable results to algorithms using both detection and tracking	In presence of stop lines at cross walks, nearby vehicles detection not proper
C. Mu et. al. [3]	Piecewise linear transformation	Segmentation by OTSU method and threshold selection	Sobel edge detection and lane markers detection by piecewise fitting	Good lane detection during the dim light environment	little false lane detection results because feature based method is usually affected by intensity of image
Parajuli et. al. [4]	Local gradient features	Linear prediction model		This method is to track the road lane markers of various shapes (curved or straight) and locate precise lane marking points on each horizontal and other low illumination conditions.	It gives more false alarms.
Y.Li et. al. [5]	Edges feature extraction and grouping	Kalman filter and Hough transform		Suitable for straight roads	Poor performance in heavy traffic and confusing road textures
J.Wang et. al. [6]	Threshold method (OTSU method)	Inverse perspective mapping		Urban lane detection	Not susceptible to interference effect
S. Srivasta-va et. al. [7]	Hybrid median filter	Edges detection algorithm	Hough transform	Computational complexity of Hough transform is optimum	This method fail to give efficient results when there is any kind of noise in road images.

Bing Yu et. al. [8]	Gaussian filter	Linear parabolic model		Less parameters are used to detect lane departure than CCP or TLC	Complex roads cannot be detected
Qing lin et. al. [9]	Sobel operator with non maximum suppression	Directional edges gap closing and Hough transform		Adaptive to various road conditions	False lane detection also occurs
V. Bottazzi et. al. [10]	Histogram	Segmentation	Lucas Kanade tracking	Robust in illumination changes	High false positives rate
C. Guo [11]	Cascade lane feature detector	Catmull Rom splines	Particle filter based on weighted graph	Robust in various lightening and weather condition.	
Y.C. Leng and C. L. Chen [12]	Sobel operator	Hough transform		Suitable for urban roads	
H. Jung et.al. [13]	Steerable filter	Haar like feature		Robust in illumination changes	
S. Zhou et. al. [14]	Lane model is obtained using the camera parameters	Gabor filter based lane matching algorithm		Robust in noise and shadows	
H.Tan et. al. [15]	Improved river flow	Hough transform		Suitable for straight and curve road	
V. Gaikwad et.al. [16]	Piecewise stretching function	Hough transform		Suitable for straight and curve road	It cannot denote which lane departure occurs.

III. PERFORMANCE ANALYSIS PARAMETERS USED FOR LANE DETECTIN AND TRACKING:

The performance evaluation of the lane detection and tracking algorithm can be done by determining whether there is a true positives (TP), false positive (FP), true negative (TN) and false negative (FN) after comparing with the ground data set. When the true ground data set is determined by the algorithm then true positive occurs. False positives occur when the lane markers are detected by the algorithm and there is no ground truth exists in the image. False negatives occur when there ground truth exists in the image and the algorithm does not detect it. True negative occurs when there is no ground truth exists in the image and the algorithm is not detecting anything in the image.

The common metrics used for evaluating the performance of the lane detection are precision, recall, accuracy and receiver operating characteristics (ROC) [17][18]. Precision is the fraction of the detected lane stripes to the actual lane stripes. Recall is fraction of the actual lane stripes to the detected lane stripes. Accuracy the measure of the how well the lane stripes are correctly detected compared to other algorithms. The ROC is the curve plot that examines the relation between the true positive rate and the false positive rate.

Precision = TP/ (FP+TP) (1)

Recall= TP/ (TP+FN) (2)

Accuracy = (TP+TN)/ (TP+TN+FP+FN) (3)

IV.CONCLUSION:

The detailed analysis of various lane detection and tracking algorithm is discussed. Different methods and techniques presented by different authors for the lane detection and tracking during the last decades are presented in the paper. Various performance parameters required to detect the accuracy of the algorithm is discussed in these paper. The lane detection techniques play a significant role in Advance cruise control. The vision based approach is very easy and simple approach for detecting lanes. A lot of advancement has been done in the lane detecting and tracking but still there is a scope of enhancement due to wide variability in the lane environments.

ACKNOWLEDGMENT:

The author would like to express his sincere thanks to Prof. A. B. Deshmukh for his support, co-operation and valuable suggestions.

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