A RELIABLE LANE DETECTION AND TRACKING FOR AUTOMATED DRIVERLESS CARS

[1]Dr.N.Shanmugasundaram, [2]L.Gowrijayasree

[1]Professor (HOD), [2]Second year, VLSI Design
Department of ECE,
Sri Eshwar College of Engineering, Coimbatore.

***Abstract*: This paper presents Lane detection and a Lane tracking system using Hough Transform and a Kalman filtering method. Primarily the image horizon is recorded from traffic congestion. The image is pre-processed to remove noise. A 2-Dimensional FIR filtering is made to detect the edges from the given input. Hough transform is used to find the lane markings or lane boundaries from the filter output. Thresholding is done to get the available Hough peak which forms the actual lane detection. The detected peaks are continuously tracked in consecutive video frames and given to Kalman filter which smoothens the output of lane tracking system. Additionally lane warning feature is added with lane tracking system.**

***Keywords*: Lane Detection, Lane Tracking, Kalman filter.**

I.INTRODUCTION

Motorist safety on the roadways has been an area of interest for many years. With the development of optical sensors at reduced cars and increased speed of microprocessors lane detection and tracking systems started to appear in markets. The future of the automotive sector lies in innovation and automation. Hence, the automotive players are now focusing on driverless or autonomous vehicles. Companies like Daimler, uber, tesla,..,etc. are investing significant time in developing autonomous vehicles.

For driverless cars, congestion avoidance is the major area of research and development. Lane detection is the important perception for congestion avoidance. Effective monitoring of the position of a car within a lane could be used to help avert a collision due to driver distractions. Lane detection technology is essential for lateral services such as Lane Departure Warning system (LDWs) and Lane Keeping Assistance system(LKAs). It could be a principal criterion to decide forward obstacle could affect ego vehicle or not. In another word, lane detection could not only affect longitudinal systems such as Autonomous Emergency Braking system (AEBs), Forward Collision Warning system (FCWs), and Adaptive Cruise Control system (ACCs) but also indirectly affect full spectrum of the automated driving system [1].

In this paper, we address some of the image processing challenges in designing a lane detection system. It is organized as follows. After a brief survey of some previous research, we then describe the various components of the system. These include image pre-processing, edge detection, a Hough transform for detecting candidate lane markers, and tracking of the lane parameters using a Kalman Filter. It is shown that this system exhibits considerable improvement in performance compared to a system using only the Hough transform and matched filtering that was previously described [2].

II. LITERATURE SURVEY

Y. Wang et al. [3] introduced "lane detection and tracking using b-snake algorithm". Here without using any cameras parameters, the lane detection and identification is proposed. The lane structures are described by the B-snake model. By using a set of control points B-spline can form any arbitrary shape. Also to determine the control points of the B-Snake model, Minimum Mean Square Error (MMSE) is proposed. This method is robust against noise, shadows, and illumination variations in the road images.

M. Aly [4] introduced "A Real time detection of lane markers in urban streets". This algorithm is robust and real time efficient for detecting lanes in urban streets. 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 road image. Then RANSAC fitting technique is used to identify the lanes. This technique gives good result in all-weather condition but still there are some false positives.

Y. C. Leng et al. [5] introduced "vision base lane departure detection system in urban traffic scenes". The Sobel operator is used to identify 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. Then both (left and right) lane boundaries width is determined using the width of the lane. Then the lane departure can be identified by the position of the lane boundary.

S. Zhou et al [6] introduced "A novel lane detection based on geometrical model and Gabor filter". This algorithm contains three modules: lane model generation, parameter estimation and matching. 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 algorithm is used to detect the lane boundaries. At last matching algorithm is used to identify the curvature of the road.

C. Guo et al. [7] 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 identification 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, splitted and merged lanes.

J. Wang et al. [8] introduced “An approach of lane detection based on Inverse Perspective Mapping”. The input image is converted to binary image using the optimal threshold. Inverse perspective mapping is done to avoid the perspective effect. Then to partition n samples to k clusters, the K means clustering is performed. B-spline fitting is used to obtain lane markers by considering all the cluster points as control points.
C. Mu et al. [9] introduced “Lane detection based on object segmentation and piecewise fitting”. The image captured by the camera is then converted to gray 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 identify 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.
H. Tan et al. [10] 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 partition into two regions: near 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. Bottazzi et al. [11] introduced “Adaptive region of interest based on HSV histogram for lane marks detection”. The lane detection method is based on the histogram. Using earliers 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 detect the lanes.

The below table summarises the methodology used by different authors and their consequences:

AUTHORS	METHODOLGY USED	ADVANTAGES	DISADVANTAGES
Y. Wang et al.[3]	Canny/Hough Estimation.	This algorithm is proposed without using camera parameters.	The problem of detecting the mid line of the lane.
M. Aly [4]	Inverse perspective Mapping and Gaussian filter.	Good lane detection during the dim light environment.	little false lane detection.
Y. C. Leng et al. [5]	Sobel operator.	Straight lanes are detected well.	Narrow lanes are difficult.
C. Guo et al. [7]	Cascade lane feature Detector.	Good in various lightening and weather condition.	Fails in some natural conditions.
J. Wang et al. [8]	OTSU Method.	Urban condition.	Not susceptible to interference effect.
H. Tan et al. [10]	Improved river flow.	Suitable for straight and curve road.	
V.Bottazzi et al. [11]	Lucas Kanade tracking.	Robust in illumination Changes.	High false positives Rate.

Table 1.1 Comparison of various lane detection methodologies.

III. METHODOLOGY

3.1 INPUT IMAGE

The use of color in image processing is motivated by two principal factors. First, color is a powerful descriptor that often simplifies object identification and extraction from a scene. Second, humans can discern thousands of color shades of gray. In other words, an image is an enormous two-dimensional array of color values, pixels, each of them coded on 3 bytes, representing the three primary colors. This allows the image to contain a total of 256x256x256 = 16.8 million different colors. This technique is also known as RGB encoding, and is specifically adapted to human vision [12]. Here the input image considered is in RGB format.

3.2 PRE-PROCESSING

In pre-processing the image in RGB format is converted to Gray scale image in order to remove external noise. Gray scale image is an image in which the value of each pixel is a single sample, that is, it carries only intensity information. Grayscale images have many shades of gray in between. Grayscale images are also called monochromatic, denoting the absence of any chromatic variation.

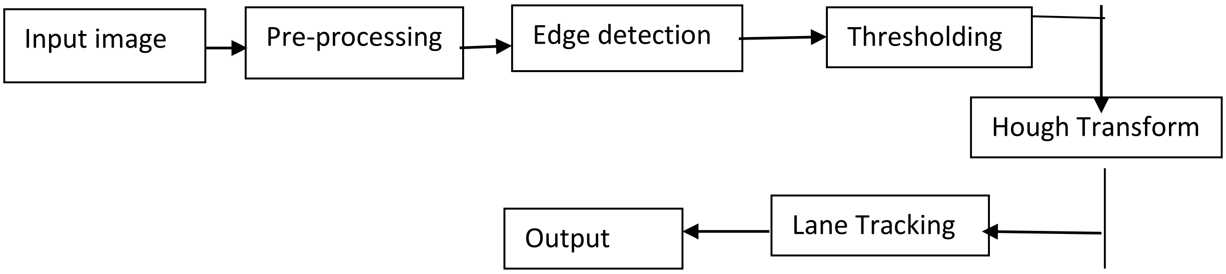

Fig 1.1 Block diagram representation.

3.3 EDGE DETECTION

Edge detection is the most common approach in finding the meaningful discontinuities in the gray level. An edge is a set of connected pixels that lie on the boundary between two regions. An ideal edge according to this model is a set of connected pixel each of which is located at an orthogonal step transition in gray level. Here, the 2-D FIR filter is used to detect edges. The 2-D FIR edge detector is designed for the regions where light intensity changes slowly. It has the ability to differentiate the edge and to smooth the noises in a nosy image simultaneously.

3.4 THRESHOLDING

Thresholding is the simplest method of image segmentation. After many layers of Pre-processing stage, thresholding is the final one which is used to decide which pixels we are considered while the others are discarded based on their intensity values. In the image output from edge detection step the pixels that belong to lane-marking evidence tend to have higher intensity values. The basic idea behind binary thresholding is that all pixels that have intensity values higher than a certain threshold will be set to maximum value maxVal, while the others with intensity values below the threshold are set to zero [13]. The binary thresholding is given by the following formula:

$$dst(x,y) = \begin{cases} Maxval & \text{if } src(x,y) \geq Threshold \\ 0 & \text{otherwise} \end{cases}$$

Where dst (x, y) and src (x ,y) are respectively intensity values of the pixel in destination image and source image.

3.5 LANE DETECTION USING HOUGH TRANSFORM

The Hough Transform is a popular and relatively fast method for finding simple mathematical forms such as lines and circles in an image. It was originally developed by Hough to recognize straight lines in a binary image, and later has been developed to detect more general shapes such as curves. The basic idea behind the Hough line transform is that each point in the binary image can belong to some sets of possible lines. In general, each line is represented uniquely by a slope a and an intercept b in the slope-intercept form:

$$y = ax + b$$

The hough lines are tracked using above equation. The above equation detects the vertical lines. In this project flow, the hough transform is integerated with kalmen filter in order to tarck the lane more effeciently. The threshold used in Hough Transform is extremely important, from definition, it is "the minimum number of intersections to detect a line". The hough transform equation in polar co-ordinate form is:

$$\rho = x\cos(\theta) + y\sin(\theta)$$

where θ is the angle between the line and x axis of the image and ρ is the distance from the image origin to the line.

3.6 LANE TRACKING

Lane Tracking stage of Hough-based Lane Detection Algorithm is made by applying Kalman Filter. Working under Markov assumptions, Kalman Filter can provide a more time-effective solution to the system. Lane Tracking stage using Kalman Filter can be divided into two big steps: Kalman Filter Update and Kalman Filter Prediction. The measurement used to update the filter each frame is the best line each side outputs from Lane Detection stage. The details of each steps and the set of equations used. In this specific situation, to predict parameters of best lines in polar form (ρ, θ) in both sides using Kalman Filter, the state vector x(t) and observation vector z(t) are defined by

$x(t) = z(t)=[\ \rho_l(t)\ \rho_{l.}(t)\ \theta_l(t)\ \ \theta_{l.}(t)\ \rho_r(t)\ \ \rho_{r.}(t)\ \theta_r(t)\ \theta_{r.}(t)]^T$

Where ρ_l and θ_l are position parameters of left-side line in polar form, $\rho_{l.}$ and $\theta_{l.}$ are the derivatives of ρl and θl which are approximated by the differences between two consecutive time frames. ρ_r, $\rho_{r.}$, θ_r and $\theta_{r.}$ are similar parameters to track right-side line. Thus, the lane markings in left and right side are continuously detected and tracked.

IV. EXPERIMENTAL RESULTS

The results displayed here are simulated using MATLAB (R2019) software.
The input image considered and it is pre-processed as shown:

Fig 1.2 input image and pre-processed image.

The pre-processed images are applied thersholding and 2-D FIR filter to dedect edges. Then the graph showing availability of hough peaks and detection left lane markings are shown:

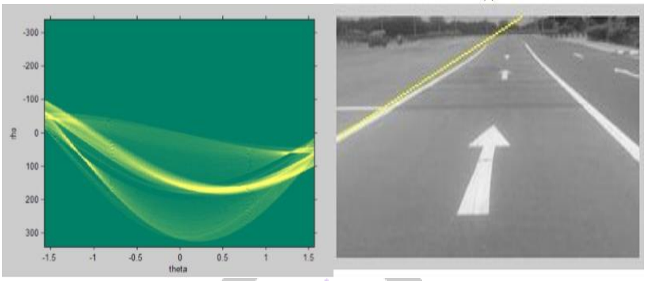

Fig 1.3 hough peaks and left lane marker detection.

The detected lanes are continuously processed by recording a video in the form of frames. The frames in which the lanes are continuously tracked:

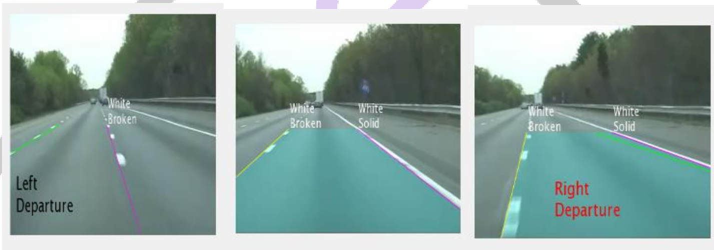

Fig 1.4 lane tracking from different frames

V. CONCLUSION

In this project, a lane detection system for departure warning based on video sequences taken from a driving vehicle was proposed. The input video sequences are processed using an image processing techniques and implemented with Matlab. As most of the lane marks are straight, lanes are detected using Hough transformation. The proposed system can detect road lane markers in a video stream and an unintended departure from the lane. Unwanted noise on the road image is filtered with 2D FIR. Finally a Kalman filter is used to track the detected lane and to smoothening the output. The intended working environment is rather common, without challenging scenarios. Therefore, the working speed of the algorithm is the top priority. The system can also process low quality video sequences where lane markers might be difficult to see or are hidden behind objects. In such cases, the proposed system waits for a lane marker to appear in multiple frames before it considers the marker to be valid. Although the system can work efficiently on fewer curves lanes, challenges occur from curved roads.

REFERENCES

[1] Moon-Hyung Song, Chang-il Kim, Jong-Min Kim, Kwang-Soo Lee,(2017), “A Novel Approach to the Enhancement of Lane Estimator by using Kalman Filter” 17th International Conference on Control, Automation and Systems (ICCAS), 978-89-93215-13-7/17/$31.00,pp:1078-1082.(Kalman-01).

[2] A. Borkar, M. Hayes, M. Smith, and S. Pankanti, “A layered approachtorobustlanedetectionatnight,” in2009IEEEWorkshop on Computational Intelligence in Vehicles and Vehicular Systems, 2009, pp. 51–57.(Kalman-01-01)

[3] Y. Wang, E. K. Teoh, and D. Shen, “Lane detection and tracking using BSnake,” Image Vis. Comput. Vol.22, no. 4, pp. 269-280, Apr. 2004.

[4] M. Aly, “Real time detection of lane markers in urban streeets,” in Proc . IEEE In-tell. Veh. Symp. Einddhoven, Thr Netherlands, pp. 7-12, 2008.

[5] Y.-C. Leng and C.-L. Chen, "Vision-based lane departure detection system in urban traffic scenes," in Control Automation Robotics Vision (ICARCV), 2010 11th International Conference on , 2010, pp. 1875- 1880.

[6] S.Zhou, Y.Jiang, J. Xi, J. Gong, G. Xiong, and H. Chen, "A novel lane detection based on geometrical model and gabor filter," in Intelligent Vehicles Symposium (IV), 2010 IEEE , June 2010, pp. 59-64.

[7] C.Guo, S.Mita, and D.McAllester, "Lane detection and tracking in challenging environments based on a weighted graph and integrated cues," in Proc. Int. Conf. on IEEE/RSJ Intelligent Robots and Systems,Taipei, Taiwan, Oct. 2010, pp. 6643-6650.

[8] J.Wang, T.Mei, B. Kong, and H.Wei, “An approach of lane detection based on In-verse Perspective Mapping,” In Intelligent Transportation Systems (ITSC), IEEE 17th International Conference on pp. 35-3, IEEE, 2014.

[9] C. Mu and X. Ma, "Lane detection based on object segmentation and piecewise fit-ting," TELKOMNIKA Indonesian J. Elect. Eng., vol. 12, no. 5, pp. 3491-3500, May 2014.
[10] H.Tan, Y. Zhou, Y.Zhu, D.Yao, and K. Li, "A novel curve lane detection based on Improved River Flow and RANSAC," In Intelligent Transportation Systems (ITSC), 2014 IEEE 17th International Conference on, pp.133-138, IEEE, 2014.
[11] V.S.Bottazzi, P.V.Borges, B.Stantic, "Adaptive regions of interest based on HSV histograms for lane marks detection". In Robot Intelligence Technology and Applications 2, pp. 677-687, Springer International Publishing, 2014.
[12] Rafael C. Gonzales, Richard E. Woods, Steven L. Eddins. (2011) "Digital image processing using MATLAB".
[13] The OpenCV Reference Manual - Release 2.4.13.2. OpenCV Dev Team, February 2017
[14] Rafael C. Gonzales, Richard E. Woods.(2010) "Digital image processing", third Edition, Pearson Education.