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Review on Lane Departure Detection Methods

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Abstract: Lane Departure Warning System (LDWS) is advanced technology used now days and developed for assisting the driver. The main purpose is to detect the lanes and warn the driver for lane departure. Various techniques are available for detection of lanes. This paper describes different lane detection methods. The most effective technique is FPGA based Hough transform which shows reduced logic area and optimum memory utilization.

Keywords: Lane departure warning systems, Lane keeping, Lane detection, Hough transform,

I. INTRODUCTION

In automated vehicle system, a lane departure warning system is a mechanism designed to warn the driver when the vehicle is about to cross its lane on roads without a turn signal. These systems are designed to minimize accidents by addressing the main reasons behind the collision like driver inattention, distractions and drowsiness.In the future, vehicles become more automated and will assist the driver for safe journey. The Advanced Driver Assistance Systems (ADAS) [4] offers several facilities like night vision assistance, lane departure warning system (LDWS), pedestrian detection, cruise control, etc. Today the reliability and the performance of the many algorithms have been significantly improved due to the increasing performance of computers. This in turn acknowledged as a powerful and versatile sensor to measure motion, position and structure of the focused area. If such algorithms are developed for such modern vision systems, then the system will increase its performance. With increase in the challenges in identifying the road lanes, robust algorithms must be used to detect straight line detection.

A. Lane

A lane is a part of a roadway that is designated for use by a single line of vehicles. It is used to give direction to the driver and also help in reducing traffic conflicts. For traffic in each direction, there are at least two lanes on the roads and lane markings are used to separate them. Lanes are specified by road surface markings on multilane roadways and busier two lane roads.

B. Lane detection

In the lane detection the detection algorithm detects the lane boundaries and estimates the straight line in geometry of lane. The Lane Detection Algorithm supports various applications: (1) Lane departure warning – give a warning when the vehicle is crossing the lane without any warning signal. (2) Lane keeping assist – when the vehicle is crossing the lane unintentionally, automatically steering torque is applied to prevent the vehicle from exiting the lane. (3) Lane centering – In this the steering wheel is always in control to keep the vehicle in the lane center. This application is a crucial component in autonomous driving systems. There are different approaches for the lane detection algorithm, such as B-snake, Histogram based segmentation, Edge linking and Hough transform.

C. Lane Departure Warning

The lane departure warning system (LDWS) uses the information from the lane detection, to estimate if the vehicle is unintentionally cross the lane boundary within the next few second. If the driver did not show any signal to switch lanes, a warning is issued. The warning mechanism depends upon sensitivity – for example, this system is used to warn only when the vehicle is actually crossing the lane, or give an early warning, before lane are crossed. The warning can be any mode like LED light, vibrating steering or beep. This can be designed based the type of road – for example, it will provide the driver with more slack for narrow roads or allow the driver to “cut” curves.

1) Methods of Lane Departure Warning System:

Firstly LDWS used in Europe and that was developed by the United States Company Iteris for commercial trucks. In 2000 they started their production, and the system is now available on most the vehicles.In 2002, the Iteris system became available on North American vehicles. In both these systems, the driver is warned if there is lane departures by an audible sound generated.Systems which warn the driver is Lane Departure Warning system (LDWS) and it is used if the vehicle is leaving its lane (visual, audible, vibration warnings)Lane Keeping System (LKS) Systems also warn the driver and, if no action is taken, automatically take actions to keep the vehicle stays in its lane.

Sensor type Method:

Lane warning systems are based on:

- Video sensors – These sensors are mounted behind the windshield, which are integrated beside the rear mirror
- Laser sensors - These sensors are mounted on the front of the vehicle
- Infrared sensors - These sensors are mounted either behind the windshield or under the vehicle

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Lane Keeping Method:
Lane Keeping Assist is features that in addition to Lane Departure Warning System which automatically take actions to ensure the vehicle do not cross its lane. Some vehicles also add adaptive cruise control with this to provide more safety.

While the combination of these features makes a semi-autonomous vehicle, most vehicles require the driver should keep the vehicle under control while it is in use. This is because of the limitations associated with the lane-keeping feature.

A lane keeping assist mechanism can either reactively turn a vehicle back into the lane if it starts to leave or keep the vehicle in the center of the lane. Now a day's vehicle companies often use Lane Keeping Assist which includes both Lane Keep Assist (LKA) and Lane Centering Assist (LCA) but the terms are beginning to be differentiated.

2) Working of LDWS:
Lane departure warning employs a simple camera. The camera plus processing software used to watch how close the vehicle is to lane markings. It gives signal to driver when he is about to cross, but only if your turn signal isn't on.

How it works:
The most common LDW system uses a camera location at front side of vehicle. It continuously captures a front view of the road ahead. The image is used further for digital processing. The driver supposed to center the car between the two lines. If the car unintentionally approaches or reaches the lane marking, the driver gets a warning. If the turn signal is on, then the car gives no warning. That's lane departure warning.

II. RELATED WORK

Heechul Jung, Junggon Min and Junmo Kim [1] applied Haar-like features to detect the lane efficiently. Furthermore, they presented a hypothesis generation and verification method using an assumption based on the camera installation constraints.

In the hypotheses generation, first each lane (left, right) is computed from the detected points using the following equation.

$$I_1 = P_1 \times P_3 , \; I_2 = P_4 \times P_6 \qquad (1)$$

I_1 and I_2 represent the left and right lanes, respectively. In world coordinates, the two lanes are parallel, so the extracted lines (I_1 , I_2) should be converged at infinity. The vanishing point, which is the point at infinity, is calculated using the following equation.

$$V = I_1 \times I_2 \qquad (2)$$

The above process is clearly expressed in Fig 1.

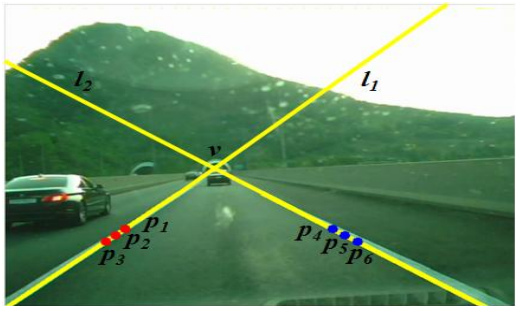

Fig 1 Candidate Points p1::::: p6, Produced Two Lines l1; l2 using each Candidate Point, v is Vanishing Point

Hypothesis verification is performed for two lanes I_1 and, I_2 and for vanishing point v. The lane verification is performed to check if each extracted lane is correct or not. This is performed by calculating the distance between a point and a line but it can be a heavy task for low power computing system if the number of points is increased.
As a result, this algorithm achieved a 90.16% detection rate; the processing time was approximately 0.12 milliseconds per frame. The disadvantage of this algorithm is whole system is based on one assumption that the camera is installed at the center of the vehicle.

Qing Lin and Youngjoon Han [2] presented a real-time lane departure detection system. In the proposed lane detection method, lane hypothesis generation and verification is done based on an effective combination of lane-mark features. First, region of interest (ROI) is decided and lane-mark candidates are searched inside ROI. During this searching process, directional edge-gap closing is used in an extended edge-linking algorithm. This process produces more complete edge-links, and features like lane-mark width and lane-mark edge orientation. In the verification method of lane-mark candidates, firstly color is checked inside the region enclosed by candidate edge-link pairs in YUV color space.

Additionally, this algorithm shows one advantage like; there are no special requirements for camera parameters, background models, or any other road surface models.
Finally, a simple lane departure model is built to detect lane departures based on lane detection module. Experiment results show that the proposed lane detection method can give an average speed of 30~50ms per frame with over 92% as a correct detection rate. The disadvantages of this system are there is faulty detection where non-lane objects are detected as lane.

Gregory Taubel, Rohit Sharma, Jiann-Shiou Yang [3] presented the use of rumble strips on roads in their paper. However, rumble strips do not exist on a majority of roadways and require an infrastructure. They present an image-based LDW system by integrating the L-K optical flow method and the Hough transform-based lane detection method. The L-K point tracking is used when the lane boundaries cannot be found, while the lane detection technique is used when they become available. Even though both the L-K optical flow and lane detection

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techniques are used in our system, only one method is activated at any given time. Based on the implemented hardware/software system, they conducted several road tests and found a false alarm occurred only roughly about 1.18% of the operation time. To characterize the vehicle lateral characteristics, this approach only needs the minimal set of information but in turn the system become slow.

Prof. Sachin Sharma and Dr. D. J. Shah [4] used Hough transform to detect the lane markings and ROI segmentation technique. Proposed method measures the distance between the lanes. They use it to make out decision for left or right departure. Research shows that the proposed algorithm accurately detects the lanes in short span of time.

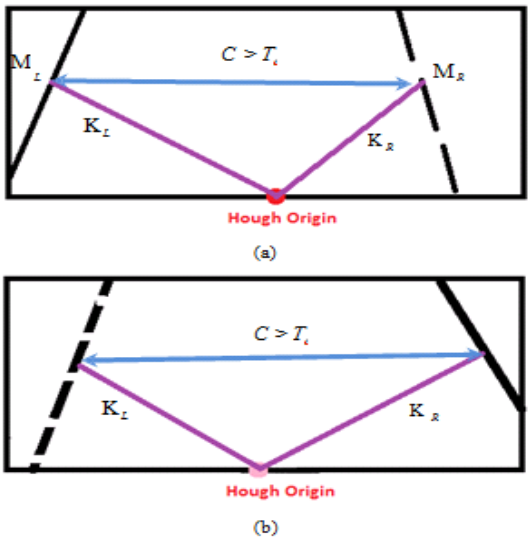

Fig 2 Lane Departure Calculation on ROI (a) Left departure, (b) Right departure

In this first, ROI of an image is extracted. Edges in an image are detected using Hough transform. H_0 is Hough origin which placed at the coordinate (x/ 2, 0).
Left edge mid-point and right edge mid-point M_L , M_R are calculated. A line is made from mid-point to Hough origin is plotted and its length is measured as K_L, K_R. The horizontal distance joining two mid-points is noted down as length C shown in Figure. If the value of length C is greater than initial threshold value T_i then the position of car will be examined for departure.
As shown in above Fig 2 (a), if K_R is less than K_L then car is at right lane otherwise if K_R is greater than K_L then car is at left lane. Initial thresholds are set. If one between of the length K_L, K_R reduces below some threshold T_L, T_R then lane departure on left side or right side occurs and then warning will be given to driver.

The proposed algorithm accurately detects the lanes in minimum time. The proposed algorithm shows average execution time of 0.053622 second. For lane departure warning system it is needed that the algorithm must be executed in short time to execute better accuracy so that driver will get more time to bring the car back in lane.

C. F. Wu, C. J. Lin, H. Y. Lin, H. Chung [5] used camera at the left side rear view mirror which captures the images of lane. Image processing techniques are used for the detection of lane lines. The lane candidates for vehicle are explored and verified with the characteristics, for example length, width, time duration, and height. Lastly, the distances of vehicles are measured with neuro-fuzzy network. The system results show it works well for different road conditions and for multiple vehicles. The disadvantage of this system is that it cannot detect changes in line.

III. COMPARISON OF DIFFERENT LANE DETECTION METHODS

Comparisons of discussed all papers are given in following Table 1.

TABLE I comparison of different methods

Sr. No	Methods Used	Advantages	Disadvantages
1	Lane Detection using Haar-like features	This algorithm is suitable for low computing power systems like automobile black boxes.	It does not give well accurate results
2	Real time Lane Detection Based on Extended Edge linking Algorithm	the proposed lane detection method can work robustly in real-time	Faulty detection where non-lane objects are detected as lane
3	Lane Departure Warning System Based on the Optical Flow and Hough Transform Methods	More feasible in a vehicle application.	Processing time depend on both the techniques hence system became slow
4	Lanes Detection Based On ROI segmentation and Hough Transform	It is robust against noise, high speed algorithm	It consumes more power
5	Vision-Based Neuro-Fuzzy method for Lane Detection	It deals with lane detection, vehicle identification and Lateral Vehicle Distance Measurement	It cannot detect changes in line.

IV. CONCLUSION

The conclusion of this study of existing methods has been carried out to develop a most efficient method for Lane departure detection. The previous methods proposed for detection and marking have several shortcomings. A lane departure warning system using Hough Transform has been proposed in previous method also but using FPGA

with it we can improve system performance. FPGA implementation consumes less power also it is very compact and fast.

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