WHITEPAPER

Advanced Driver Assistance Systems:
A Cost-Effective Implementation of the Lane Departure Warning System

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Abstract

A lane departure warning system (LDWS) is defined as system that warns the driver when an unintentional lane departure is about to occur. This system can assist drivers to maintain proper driving within the lane and also warn the driver when the vehicle is departing from current lane so that driver is alerted to take appropriate action. This system comes under application of ADAS.

LDWS monitors the position of vehicle with respect to boundary. When the vehicle is in danger of leaving the lane unintentionally, since the driver is not paying full attention to the road ahead, the system delivers the warning to driver.

L&T Technology Services has developed a Vision-based Lane Departure Warning System (LDWS) for intelligent Advanced Driver Assistance Systems applications. An important component of ADAS is evaluation of sequences of images recorded with real time camera mounted on moving vehicle. Sequence of images gives information about the automotive environment which has to be analyzed to support the driver.

This paper focuses on the implementation carried out for Cost effective LDWS that can be applied for Low and Medium range vehicles. This paper also talks about the Verification of the developed algorithms using live videos as well as a Simulator.

Keywords: ADAS, Lane Departure Warning system, Active safety system, Image processing algorithm, Lane departure, Lane Detection, Vision based.

1. Introduction

With the advent of requirement to provide Advanced Driver Assistance Systems in Mid-and-Low Cost Car segments, usage of cost-effective Sensors has become imperative. Usually, High-end Cars have Radar, Lidar and similar systems to implement ADAS.

At L&T Technology Services, we have come up with a cost effective and optimized methodology, so that our system can be adopted by low and medium range vehicles. Also we have simulated our system with extremely adverse scenarios in order to make sure it will be robust in any climate.

Cameras are a suitable solution for this kind of requirement, even when Cameras are used, usage of Monocular single Cameras prove the most challenging but also turn out to be economical and thus, have a cost-advantage.

2. Solution Overview

To demonstrate our system, we developed a prototype which completely depends on image processing algorithms. To analyze the computer vision, image processing algorithms are necessary. All algorithms are developed in-house with minimum dependency on OpenCV — which is an open source computer vision library by Intel.

The following is the block diagram of the Lane Departure Warning System (LDWS):

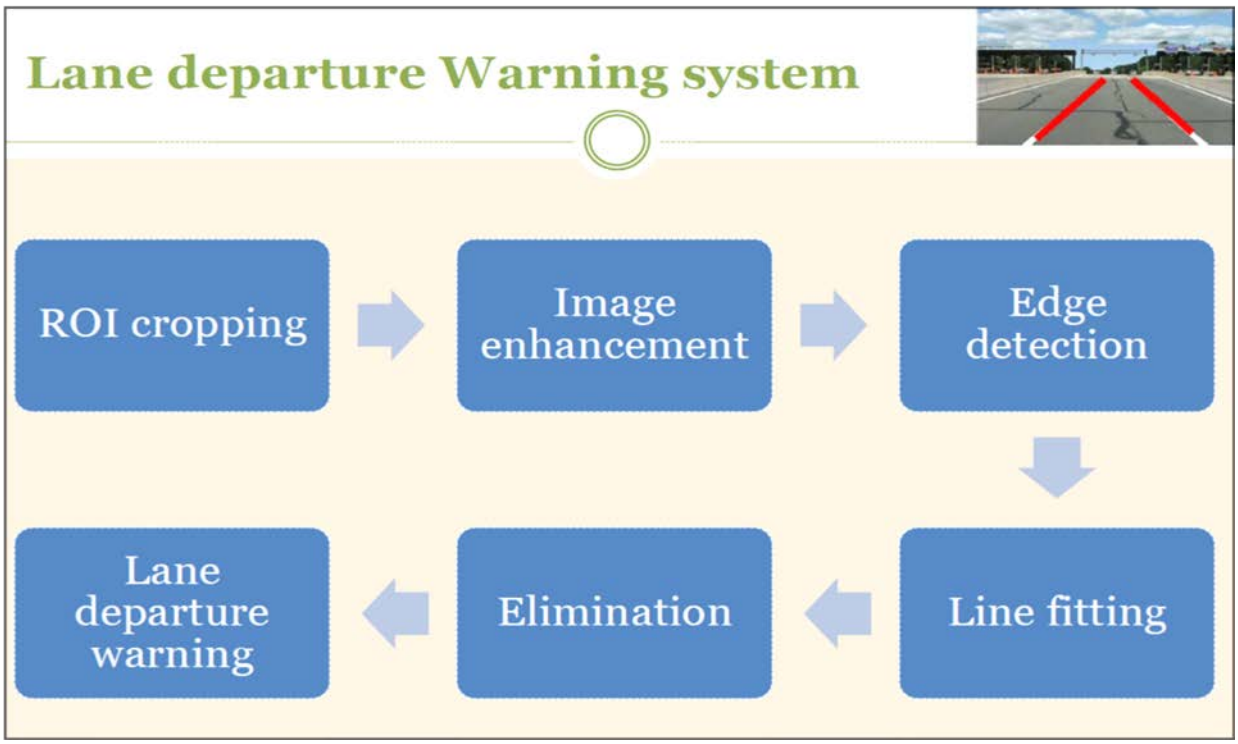


Fig.1: Block diagram of LDWS

2.1 Development

At L&T Technology Services, we follow the V model for S/W development life cycle.

With reference to IEEE Papers, suitable algorithms are selected. Selection of the algorithm is done not only based on theoretical reference but also based on the trial and error method, in which execution time & performance factors play a major role.

Tools used to develop our algorithm are MS Visual studio 2012, OpenCV library, Eclipse Helios IDE.

Algorithms developed in-house:

- Region of Interest
- Median Blur
- Sobel Edge detection

- Hough Transformation
- Lane Departure warning calculation

2.2 Overview of Algorithm

The OpenCV methodology is used to fetch frames from video, to convert the frame into matrix.

(i) Image Enhancement

- First step involves selecting Region of Interest so that only core part of image is only processed.
- Raw image is blurred using median blur to remove salt and pepper noise.
- Then it is converted to HSV Plane to concentrate only on yellow and white colors in the image.

(ii) Edge Detection

Edge detection plays a vital role in Lane departure warning system, through which lanes are detected.

The algorithm adopted for this process is the canny edge detection algorithm. To make the output more precise, morphological operations are carried out over edge detected output.

(iii) Line Fitting

Once the edges are detected, the image should undergo Hough transformation in order to detect the lines. These detected lines are fitted back to the original image.

(iv) Departure warning estimation

With reference to detected lines, parameters and other factors like car width, Lane width, Position of car, vehicle's departure is calculated. Once the value exceeds the threshold value, appropriate warnings are issued via HMI.

2.3 Departure Warning

Once the vehicle crosses the threshold value, departure warnings are issued. Depending on the driver's convenience, one of the following type of warnings are issued.

a. Steering Vibration

b. Audible alert

c. Visible LED Blink

Following are the pictograms that will be displayed in HMI once the vehicle departs the lane.

Fig 2: When the vehicle is safely driving inside lanes

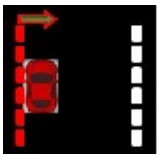


Fig 3: When the vehicle is about to cross the Left Lane

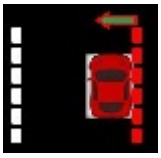


Fig 4: When the vehicle is about to cross the Right Lane

Fig 5: When the vehicle has departed from the lane completely

2.4 Avoiding False Alarm

To avoid false warnings during intended lane departures, additional information is necessary.

The following intended departures are considered:

- Lane changes which are announced by the driver using the blinker,
- Emergency maneuvers with brake and high steering activity,

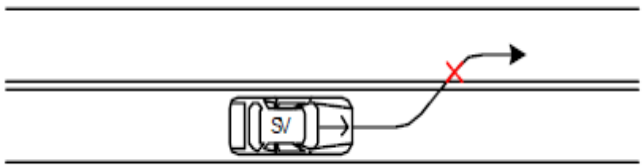
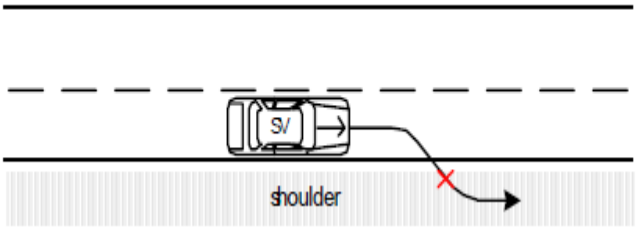
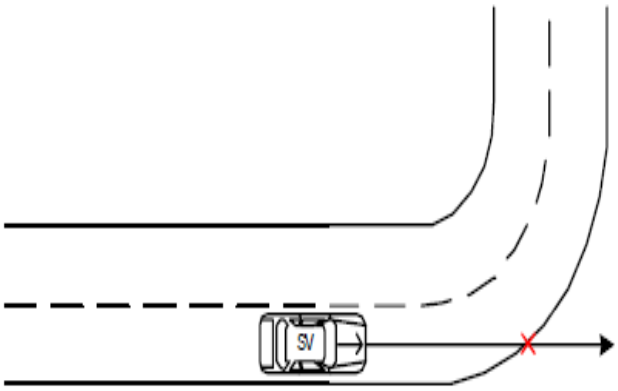
Before changing a lane, drivers are obliged to set the blinker. So, if the blinker is set while departing the lane, warnings are suppressed.

If the driver brakes, he already reacts to some situation and is most likely aware of the situation.

Additional warnings would be disturbing in such cases and are, therefore, suppressed. The same argument holds if there is a high steering activity.

2.5 Verification of Algorithm

The developed algorithms are validated using simulated scenarios before testing them on the field. The following are some of the scenarios:

S.No.	Description	Figure
i.	Subject vehicle is about to depart from the Left Edge of the double solid lane.	
ii.	Subject vehicle is about to depart from the Right Lane.	
iii.	Subject vehicle is about to depart from the Right Lane of the curved roadways.	

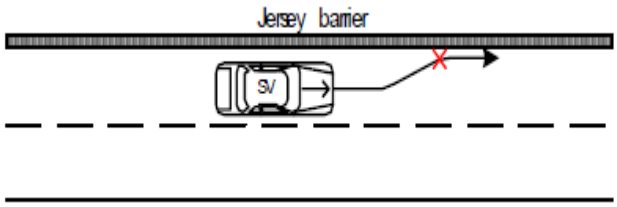
iv.	Subject vehicle is approaching a jersey barrier instead of the Lane marking.	

Fig.6: Various scenarios of LDWS

2.6 Verification System Set-up

- PC with 8 GB Graphics card
- 2 Monitors
- Logitech Game joystick set up
- Real time simulator game

In this set-up, the first monitor displays the input simulated video (fast-paced game to simulate real-life scenarios). The second monitor is used to display the processed output along with the associated warnings.

Fig.7: Snapshot of Verification system set-up

3. Project Outcomes

(i) Normal Day Scenario

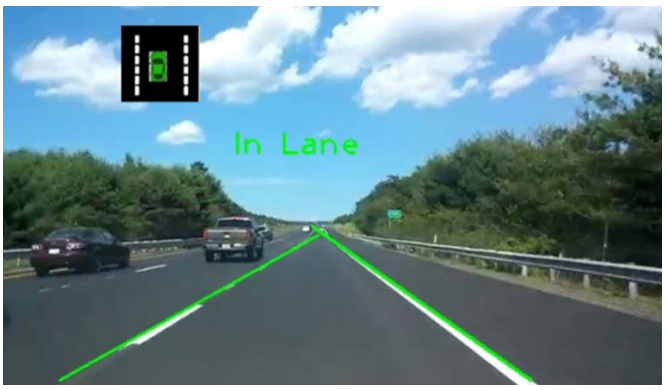


Fig.8: A vehicle is driven in between lanes without any violation in a "day" scenario

(ii) Night Scenario

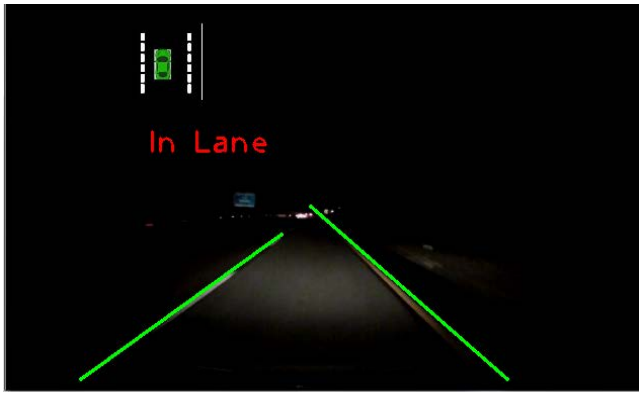


Fig.9: A vehicle is driven in between lanes without any violation in a "night" scenario

(iii) Shadow Scenario

Fig.10: A vehicle is driven in between lanes without any violation in a "shadow" scenario

(iv) Simulated output

Fig.11: A vehicle is driven in between lanes without any violation in "shadow" scenario

4. Conclusion

In this paper, a cost-effective lane departure warning system using Monocular camera is presented. The lane departure method is improved by ROI segmentation technique and color based lane detection. Monocular camera parameters like focal length, intrinsic and extrinsic parameters are used for measuring the distance between the lanes, position of the vehicle, based on which decision for left or right departure is derived. In this way accuracy in issuance of warning is improved and false warnings are reduced.

With this approach, L&T Technology Services have been able to offer an improved, optimized low-cost solution to Lane Departure Warning System. We also have the infrastructure to verify and validate the developed product, test the performance of algorithms, carry out Competitor Benchmarking and such other exercises enabling the customer to gain a competitive edge in an already mature market.

5. References

i. National Highway Traffic Safety Administration, http://www.nhtsa.dot.gov/

ii. Robert Laganiere "OpenCV 2 Computer vision Application programming cook book", Aug 2013.

iii. Bruno Keymolen "Theory of Hough Transformation" May 2013.

iv. Probabilistic and non-probabilistic Hough transforms: overview and comparisons, by Heikki, Petri, Lei Xu.

About L&T Technology Services

L&T Technology Services is a wholly-owned subsidiary of Larsen & Toubro with a focus on the Engineering Services space, partnering with a large number of Fortune 500 companies globally. We offer design and development solutions throughout the entire product development chain across various industries such as Industrial Products, Medical Devices, Automotive, Aerospace, Railways, Off-Highway & Polymer, Commercial Vehicles, Telecom & Hi-Tech, and the Process Industry. The company also offers solutions in the areas of Mechanical Engineering Services, Embedded Systems & Engineering Application Software, Product Lifecycle Management, Engineering Analytics, Power Electronics, and M2M and the Internet-of-Things (IoT).

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