WHITEPAPER

Advanced Driver Assistance Systems:
A Cost-Effective Implementation of the
Blind Spot Detection Warning Module

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L&T Technology Services

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Abstract

A typical blind spot monitoring system uses some kind of electronic detection device(s) mounted on the sides of the car (often in the vicinity of the external rear view mirrors or near the rear bumpers) that sends out either electronic electromagnetic waves (usually in the radar wavelengths) or takes computer-processed images with a digital camera and analyzes them.

L&T Technology Services has developed a Vision-based Blind Spot Detection (BSD) system for intelligent Advanced Driver Assistance Systems applications. In our system, images are analyzed using optical flow techniques and frame difference to detect pixels that move in the same direction as the ego-vehicle.

An important component of a driver assistance system 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 Blind Spot Detection solution 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, Advanced Driver Assistance Systems, Blind Spot, Ego-vehicle, Image Enhancement, Motion Estimation Direction Estimation, Object Detection, Object Classification.

1. Introduction

With the advent of a need 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 Camera proves the most challenging but is also economical & has a cost advantage.

2. Solution Overview

To demonstrate our system, we developed a prototype which relies completely 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 open source computer vision library by Intel.
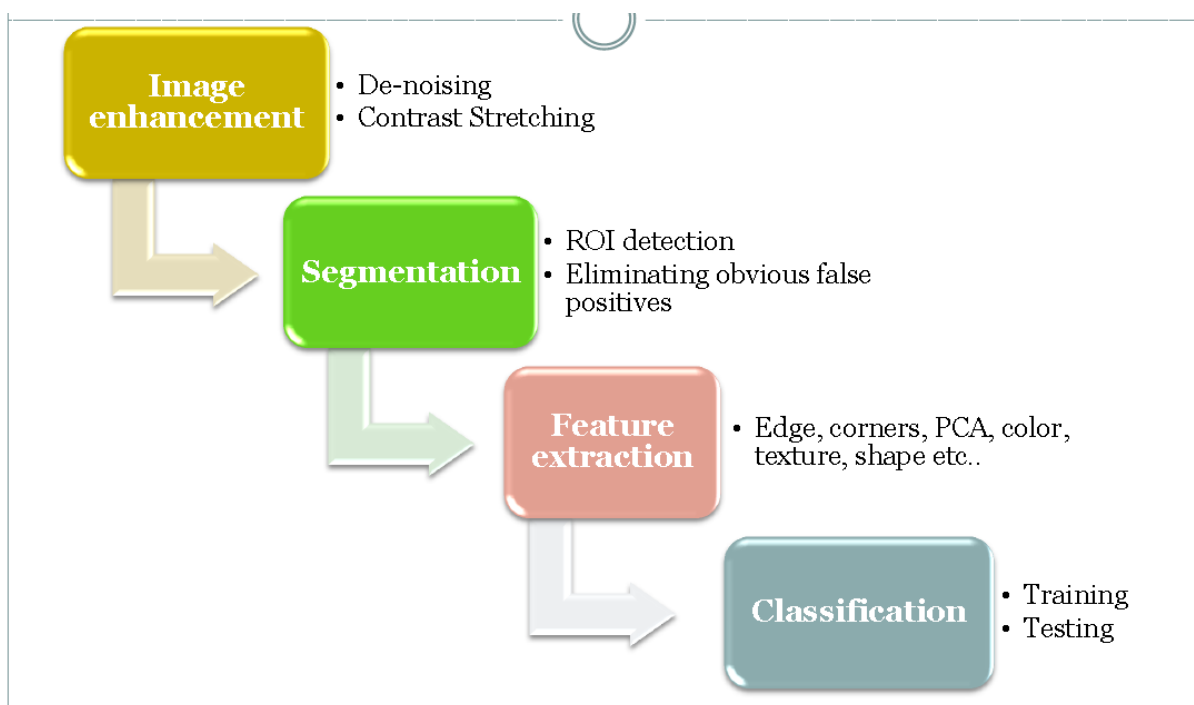

Fig.1: Block Diagram of BSW

2.1 Development

At L&T Technology Services, we are following V-model S/W development life cycle.

Using the wide range of IEEE Papers as reference, suitable algorithms are selected. Selection of algorithm is not only based on theoretical reference but also based on 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:

- Image Enhancement
- Motion Estimation
- Direction Estimation
- Object Detection
- Object Classification

2.2 Overview of Algorithm

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 processed. Raw image is blurred using median blur to remove salt and pepper noise.

(ii) Motion Estimation

Absolute Frame Difference is used for motion estimation. It calculates the per-element absolute difference between two arrays or between an array and a scalar.

(iii) Direction Estimation

Optical flow is used to compute the motion of the pixels of an image sequence. It provides a dense (point to point) pixel correspondence. Correspondence problem: determine where the pixels of an image at time t are in the image at time t+1. The number of features extracted can be varied by altering parameters.

(iv) Object Detection

Thresh-holding is carried out for object detection which converts grayscale image to a binary Image. Beyond threshold, the number of White pixels in the Frame is matched and after tracking the result for a group of frames Object Marking is done.

(v) Object Classification

Once the object is detected in the ROI region. The Haar Cascade is used for Vehicle Classification. Haar cascade works on the principle of extracting Features from a set of positive and Negative Database of Object which has to be detected.
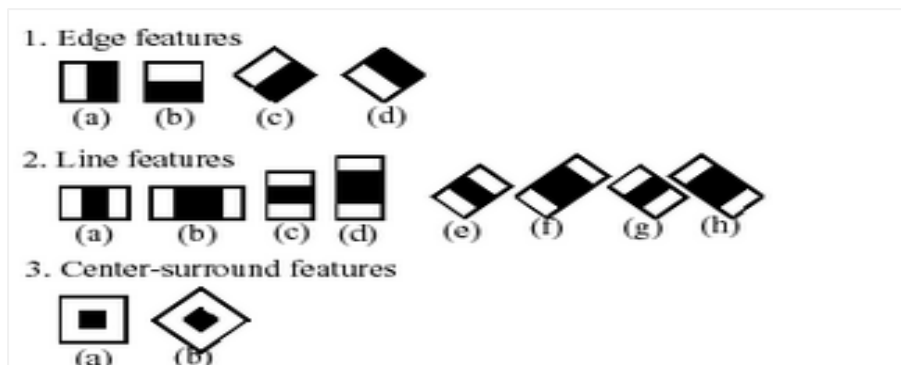
Some Common Haar features are as follows:-

Fig.2: General Haar Cascade Features

2.3   Warning Display

Warning for the BSD will be displyed by Image icons.

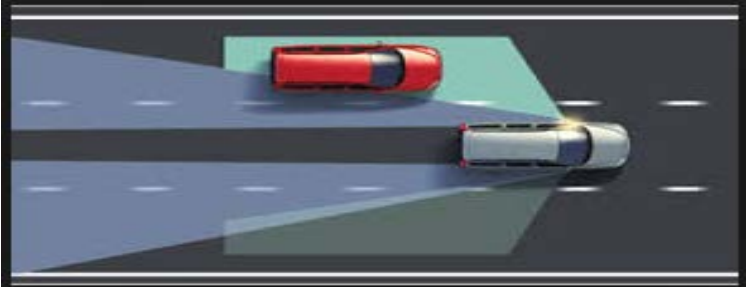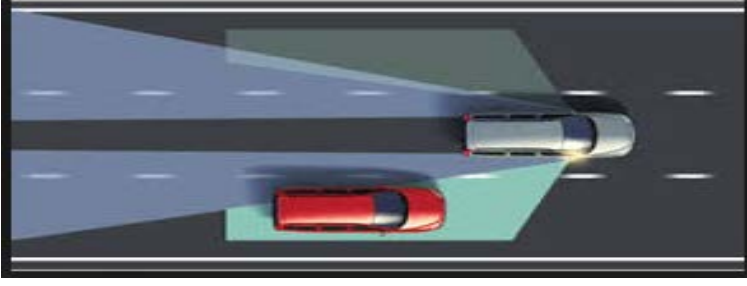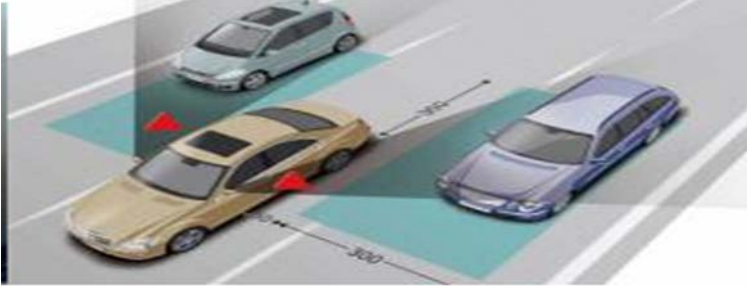**Fig 3: When BSD Region of Interest is Free (No Vehicle Condition)**
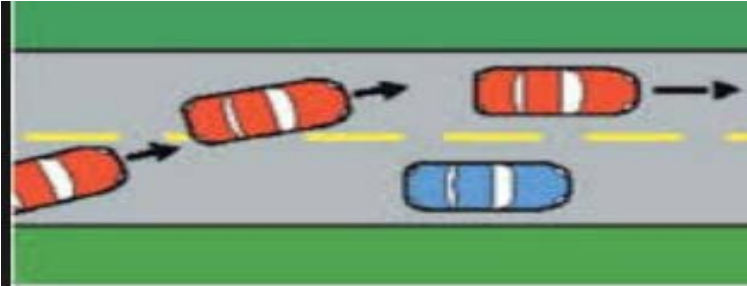

Fig 4:When BSD Region of Interest is Occupied (Vehicle Detected)

2.4   Verification of algorithm

Once the algorithm is developed, the performance of algorithm is validated using simulated scenarios.

Some of the scenarios are depicted as below:

1.	Left Blind Spot occupied	
2.	Right Blind Spot occupied	
3.	Both Blind Spot occupied	
4.	Left Blind Spot Overtaking	

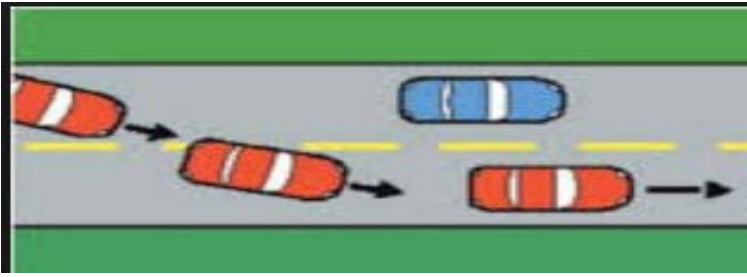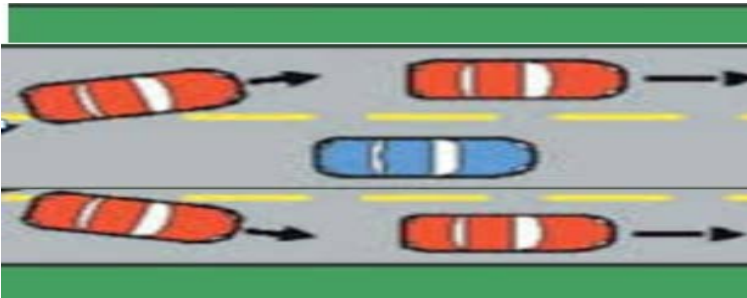| 5.	Right Blind Spot Overtaking	
6.	Both Blind Spot Overtaking	

Fig.5: Various Scenarios of BSDW

2.5 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.

Below is the snapshot of verification system set-up:

Fig.6: Snapshot of Verification System Set-up

3. Output Samples

Fig.7: BSD not Activated since no Object in Region of Interest

Fig.8: BSD Activated since Object in Region of Interest

Shown below are Output Samples for Simulator:

Fig.9: Left Blind Spot

Fig.10: Right Blind Spot

Fig.11: Lengthy Vehicle Scenario

4. Conclusion

In this paper, an improved method for Blind spot detection system has been presented. Monocular camera parameters like focal length, intrinsic and extrinsic parameters are used for estimating the Vehicle location in the ROI. Once the object is detected using frame difference to eliminate false alarms, we calculate the direction of motion of vehicles using optical flow and filter the vehicles which move in the reverse direction. With this approach, L&T Technology services have been able to offer development of image processing Algorithms in an optimized manner, verify and validate the developed product, testing the performance of algorithms, competitive benchmarking and such other exercises enabling the customer to gain a competitive edge in an already mature market and therefore re-vamping products for market re-launch.

5. References

(i) Alvarez, S., Sotelo, M.A., Llorca, D.F., Parra, I.: Vision-based target detection in road environments. In: WSEAS VIS08.

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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).

With a multi-disciplinary and multi-domain presence, we challenge ourselves every day to help clients achieve a sustainable competitive advantage through value-creating products, processes and services. Headquartered in India, with over 10,000 highly skilled professionals, 12 global delivery centers and operations in 35 locations around the world, we constantly find flexible ways of working, tailored to our assignments and customer needs.

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