

Survey on Blind-Spot Detection Systems for Improved Vehicle Safety

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Abstract— Due to the growth in road accidents, driving safety has become one of the most important issues in recent years. If drivers are aware of their surroundings and the likelihood of colliding with other vehicles, many collisions can be avoided. Blind spots are the most collision-prone areas, as drivers cannot see approaching vehicles in their front or rearview mirrors. Using either sensors or computer vision, Blind Spot Detection System (BSDS) detects vehicles in adjacent lanes that are not directly visible to the driver and alerts the driver. This study gives an overview of the image processing algorithms employed by Blind Spot Detection System for vehicle detection.

Index Terms—ADAS, BSDS, blind spot, radar, Kalman filter, Sobel filter.

I. INTRODUCTION

Road traffic injuries have become one of the main global causes of death in recent years. According to the World Health Organization's worldwide road safety status report, more than 1.2 million people die on the road each year. The majority of these fatalities occur in poor and middle-income nations, where there is rapid economic expansion as well as rising motorization and road traffic injuries. Road traffic accidents cost these countries approximately 3% of their GDP. With continued economic expansion, there will be a rise in global mobility and traffic density. The most generally identified variables leading to road traffic accidents are divided into three categories: environmental conditions, vehicle, and driver.

According to research, environmental factors such as roadway infrastructure, dynamic meteorological conditions, poor visibility, and so on may be a key cause of highway accidents in approximately 30% of occurrences. Only 10% of accidents may be caused by vehicle technical difficulties such as tyre explosions or poor maintenance. In 90% of situations, the cause of the collision could be driver mistake. The combination of the three criteria above causes a significant number of road fatalities [20]. The critical components in these instances are accident prediction before it occurs and whether this prediction can help drivers make remedial decisions while driving, thereby reducing road fatalities and their severity. The Advanced Driver Assistance Technologies (ADAS) are car systems and features that supplement the driver with important driving knowledge and assist drivers in driving in hazardous conditions. We can work to improve car safety and overall road safety with the help of such technologies.

A. Advanced Driver Assistant Systems

Advanced Driver Assistance Systems (ADAS) are systems that thrive to aid, balance and in due course alternate the driver in the complex process of regulating a vehicle. Based on their facility to take a pre-emptive measure in reducing situations and system complexity, the ADAS can be classified into two categories namely active systems and passive systems.

i) Active ADAS: The active ADAS performs preventive measures prior to the crash in order to avoid a potential mishap or reduce the severity of the disaster. The following are a few characteristics of the ADAS mechanism, as illustrated in Figure 1.

- Adaptive cruise control: With this driver assistance mechanism, the vehicle speed can be automatically reduced or increased in response to the actions of the vehicle in front of it. This feature can be greatly used in highway driving.
- Adaptive light control: This feature allows the vehicle headlight to swivel and rotate to help drivers to see better and further in darkness.

- Automatic braking: This feature enables to decrease the rigorousness of high speed impact in the circumstance of driver inattention. Hence can actually prevent collisions by declining down the vehicle to the spot where less damage is caused and fatalities are unlikely.
- Collision avoidance systems: In collision avoidance systems, a range of sensors detect the presence of other vehicles, pedestrians, and other route impediments. When the vehicle is about to collision with another vehicle or object, this system will notify the driver.
- Blind spot detection: Among the driver aids provided by the automobile manufacturers, the blind spot detection is an important feature that provides total information around the car, whether the host vehicle is moving at a high speed or normal speed.
- Lane departure warning system: The feature is capable of warning the driver to take remedial action in time, to evade striking another vehicle or going off the road, if the system determines that the vehicle is drifting.

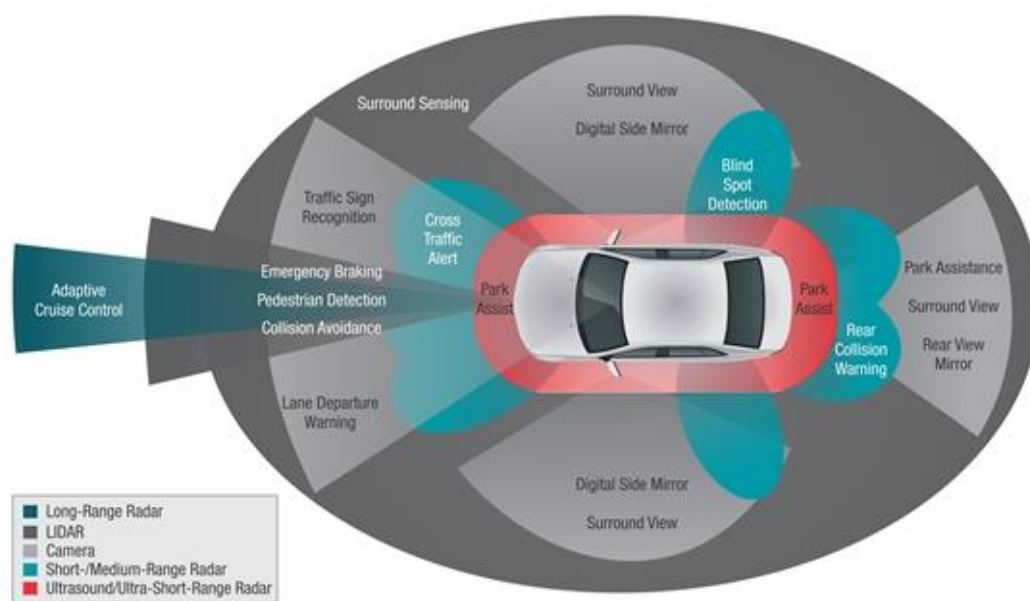


Figure.1: Advanced Driver Assistance System [21]

ii) Passive ADAS: These systems refer to the safety- entrenched technologies in the vehicles, intended at protecting the occupants and lessening the post-crash trauma. When the active safety system fails in avoiding an impending accident, the passive systems play a vital role.

B. Blind Spot Detection System: An Overview

Blind spot detection systems are one of the Advanced Driving Assistance systems that appear to enhance driving security. Blind spots are places in adjacent lanes of a road that are blocked by various vehicle structures or oblique zones that are not visible to drivers [1]. Blind spots are the areas of the road that the drivers cannot see while looking forward or through either the rearward or side mirrors, as depicted in Figure 2. The following facts concerning blind areas are highlighted through analysis [4]:

- The probable risk of encountering with an accident is three times higher, if driver changes lanes than when continuing driving in the same lane.
- Once every 2.76 miles, the drivers change lane in his average daily drive. This rate may still increase if he is driving in suburban roads.
- The vehicle will travel around 250 ft unnoticed, while driving in the speed of 70 mph with a 2 sec head turn to verify the blind spots.
- Approximately 63,000 collisions take place every year in America's highways; in which 1 out of 25 accidents is due to risky lane changes and merges.

The blind spot systems can be divided into two categories: radar-based blind spot detection systems and computer vision-based blind spot detection systems, depending on the technology used to estimate the distance of the approaching vehicle. In radar-based blind spot systems, the sensors are placed in the left and right backs of a car, either behind each rear quarter panel or after the rear bumper fascia, and they transmit and receive radio waves to and from the car's left and right blind areas. The driver is warned by the processed radar signals through visual and/or audio cues. Radars have the drawback of having their signals interfered with by weather conditions including snow, rain, and fog [13]. Additionally, it is exceedingly difficult to identify moving objects due to the short detection range.

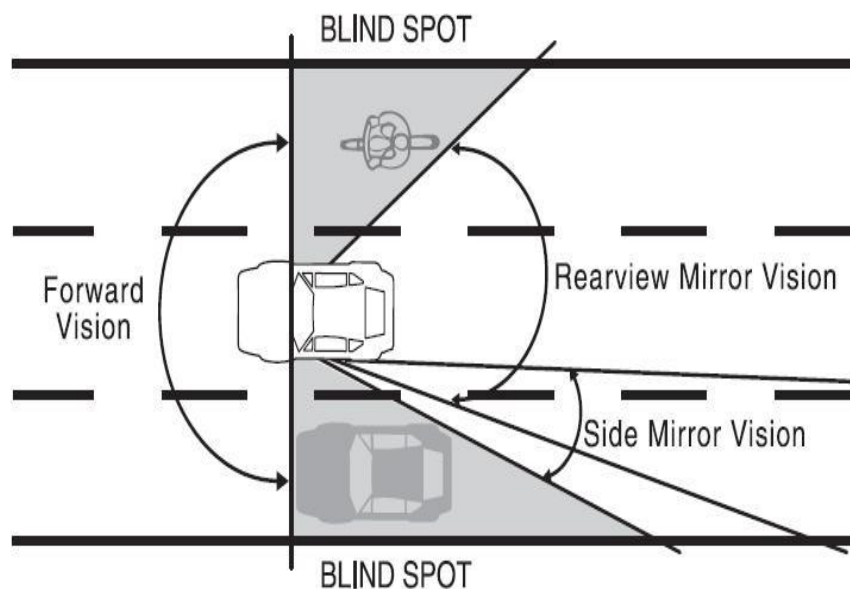


Figure.2: Blind Spot

To aid in safety and driver comfort, blind spot identification systems rely on cameras to provide a digital video feed for computer vision algorithms. The blind spot computer vision systems record a series of images with a real-time camera installed on a moving vehicle. The limitations of radars can now be more effectively overcome in vision-based blind spot systems than ever before because of the tremendous advancements in image technology. The information about the vehicle environment and other oncoming cars is contained in the camera-captured series of photos. Additionally, by using image processing techniques, the necessary information for lane marking, object/obstacle recognition, and blind spot detection is extracted and made available to the drivers as a warning. Figure 3 illustrates the typical processes taken in the detection of blind spots in BSDS.

The imaging environment in a vehicle presents many difficulties. Cameras must operate dependably in all weather conditions and at extreme temperatures, including high dynamic range scenarios with intense brightness and darkness. High resolution, the ability to identify and classify things, and the ability to provide important information are all benefits of imaging. The processed and combined visual images produce a significantly more reliable solution. Although blind spot detection systems play an important role in preventing accidents, there are some issues that must be resolved before vision-based detection systems may be implemented. The blind spot detection systems' key difficulties are:

1. When fast stirring vehicles merge in busy highways, the blind spot monitoring systems have complexity in identifying such vehicles. At present, alerts are often imparted too late for avoidance action.

2. Road circumstances are often a setback for blind spot monitoring systems. Damaged roadway markers, construction zones and crossroads can cause lane departure warning system to lose track of lane location, future posing challenge for blind spot monitoring systems.
3. The vehicle camera captured image, consists of noise and other interference information along with road information. This redundant data removal also has to be done during the image processing step in blind spot monitoring systems.
4. Recognizing the vehicle's edge features might be hard due to natural climatic conditions and may also be affected by shadow, night vision, foggy weather or other uncertain factors.
5. To avoid collision, the blind spot detection system must determine not only the vehicles in front of the same lane but also need to resolve the existence of the front vehicles of adjacent lanes of the host vehicle

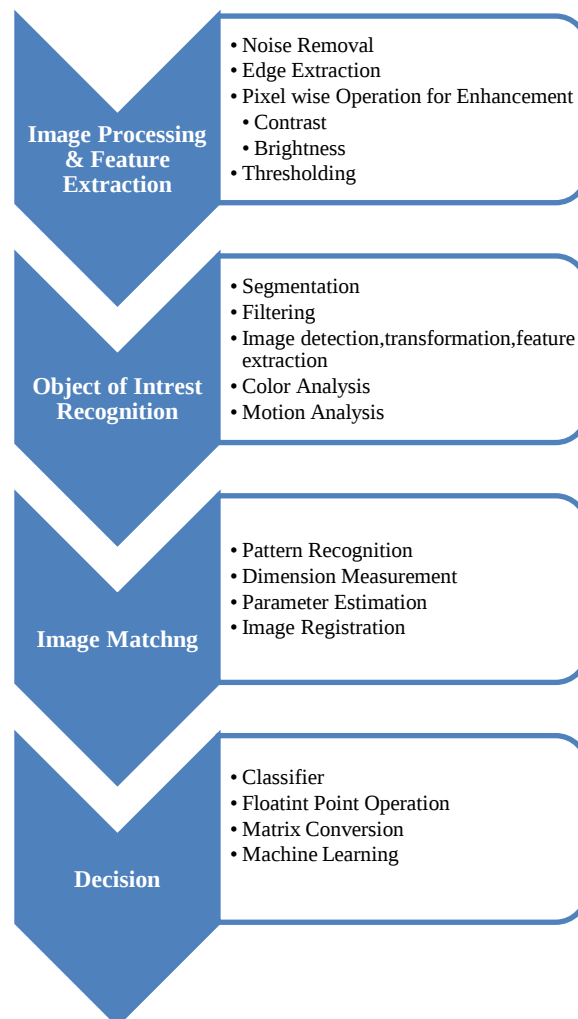


Figure.3: Steps in Blind Spot Detection System

II. RELATED WORK

This segment gives an outline about the various presented review studies related with blind spot detection system and the image processing techniques incorporated in them. Although diverse approaches have been considered in the field of Active Driver Assistance System to deal with the vehicle detection problems, some of the proposed techniques are not directly appropriate in the area as they have several limitations. In this section, a survey on the different approaches used to detect vehicles in blind spot detection system has been carried out.

An adaptive template matching method was proposed by Krips et al [2], which extracts the target by means of shadows and is differentiated by self-adjusted template and a matching score. The edges of the object

are detected and marked with white lines, using the object hypothesis methods. The detected undersize d edges are adjusted using the self-adjusting template and further, the object detection is confirmed using time and spatial constraints. The match score feature of the AdTM system identifies the false trajectories. The system provides an excellent tracking behaviour, but fails to detect images in different weather conditions.

In the system proposed by Furukawa et al [3], the object detection is done by first extracting horizontal segments from predetermined detection area and then by tracking of horizontal segments to obtain the motion.

Chen et al [5], presented an algorithm which uses 1D distance axis signal information to locate the object. The first step in the proposed system is to convert the detected region from the captured 2D image into 1D distance axis signal information of at least two neighbouring time points. The position of the object is then recognized by determining the differential value of the 1D distance-axis signal information. The thresholds are compared with the information quantities of 1D, for a minimum of two adjacent time points, to determine the vehicle's approaching status. The average accuracy of blind spot detection is 90% in speedy road, 91% in urban road and 91% in high way roads. The accuracy is deteriorated in high-speed road during rainy days.

The vehicle proposition during evening and night time is generated by the system proposed by Schamm et al [7]. The possible light candidates are identified by using the modified gauss filter kernel. The light candidates are compared for best similar candidate combinations from probable vehicle hypothesis using rule-based clustering process. The proposed system efficiently detects the rear vehicle lights but lacks in the detection of the oncoming vehicles.

A real-time embedded blind spot safety assistance system was presented by Wu et al [9]. Using an automatic threshold approach for the shadow and object segmentation, the varying light illuminations in outdoor scenes are distinguished. The captured image may consist of noise, which will be removed using the feature extraction method. The lamp verification module of the system differentiates between the headlight and reflection of the vehicle based on the intensity difference and size judgment of the bright objects. The experimental results were compared with other methods and showed that the proposed system works well in the highways and in urban roads and has improved performance both in recognition and false alarms. But, compared to other methods, the processing time of this system is high compared to other methods. This

Bing-Fei Wu et al [11], implemented a robust BSD algorithm for vehicle detection under daytime conditions. The region of interest and the shadow positions of the targeted vehicles were determined using the Horizontal Edge and Shadow Composite Region (HESCR) method. The system performs the bright segmentation of vehicles at night time using the intensities of the corresponding vehicle's headlights. Experimental results demonstrated that the system achieves accuracy up to 97% in daytime detection and up to 91% in night time detection.

Bael et al [13], proposed a robust method for a BSDS with a vision system. The relative distance and speed of the adjacent vehicles were extracted in order to identify the approaching vehicles in the side and rear blind region of the vehicle. Based on the lane model and the vehicle dynamics, the rear side lanes, and the road curvature underneath ill conditioned background image, a Perception Action Network (PAN) has been designed. The system is only ideal for an environment without traffic and noise, so the effect of noise and uncertainty has not been evaluated.

The image processing methods such as Sobel and morphological operations were repetitively used to detect the host vehicles. The unwanted background image is removed using Kalman filter from the captured image. But the system is limited to certain environments, where there is a need for further progress in vehicle detection during night, rainy, backlighting, tunnel and other such driving conditions. This algorithm for the detection and tracking of rear-side vehicles on highway roads was proposed by Baek et al [15].

Wang et al [16], proposed a unique approach to acquire the motion information from the videos. The spatio-temporal wavelet transform was applied on the videos to extract the motion information. By combining the diverse motion information extracted from the sub bands, an additive motion image was formed. The additive motion image was further processed using adaptive thresholding and connected components labeling to segment moving region. The moving region is not precise, as successive frames along temporal domain are referenced in wavelet transformation. The location calibration method is applied to overcome the inaccurate detection of moving regions of vehicles. The proposed approach is permissive to cast shadow and camera vibration. Experimental results show high precision and recall rates.

The direction of moving vehicle in blind spot area was detected in the method proposed by Jung et al [17]. The moving direction of the vehicle was determined by investigating the transition of vehicle's front in a rear-view image, the moving direction of the vehicle was determined. The ROI window position was modified along with the HOG and SVM implementation, which resulted in increased feasibility. The key advantage with respect to complexity, is it does not require high computational load. The disadvantage in the proposed system is the precision rate is less.

Kim et al [19], proposed a new approach for detecting and tracking overtaking vehicles in blind spot area at night time. The motion vector of the vehicle was determined using the blob feature of the vehicles headlight. The prominent two headlight or the detected bright blobs are grouped to comprise the headlight of behind vehicle. Based on the position and speed of paired headlights, alarm is generated. The algorithm effectively detects the overtaking vehicle, but the accuracy decreases when there are too many flawed blobs from surround vehicles of nearby buildings in downtown area.

III. CONCLUSION

One of the most popular areas for research in advanced driver assistance systems is image processing techniques in BSDS because of the potential benefits of cost-effectiveness in driving safety features of the vehicle. According to the study, there is still a need for a crucial and precise accident prediction system that can lessen traffic dangers and prevent serious crashes. The investigation also underlines that an improved method for effectively resolving the state change of the vehicles on the road is image processing. Additionally, since real-time traffic photos are used, image processing techniques are more trustworthy in detecting the presence of vehicles. As a result, such systems ought to be devoid of the vast majority of deadly dangers. This suggested study focuses more on approaching vehicle recognition features that are connected to the blind spot detection system to minimise trajectories, hence improving driving safety. Various obstacles arise during the road accident prediction in ADAS. This work has emphasised the key research concerns related to the current methodologies. In conclusion, the aforementioned survey will be helpful for the continued development and improvement of the vehicle identification techniques in BSDS.

REFERENCES

- [1] Isaac Cohen, Gerard Medioni, "Detecting and Tracking Moving Objects for Video Surveillance", IEEE Proc. Computer Vision and Pattern Recognition, 1999.
- [2] M.Krips, J. Velten, A. Kummert, A. Teuner, "AdTM tracking for blind spot collision avoidance", IEEE Intelligent Vehicles Symposium, 2004.
- [3] Kenji FURUKAWA, Ryuzo OKADA, Yasuhiro TANIGUCHI, Kazunori ONOGUCHI, "Onboard Surveillance System for Automobiles Using Image Processing", IEEE Intelligent Vehicles Symposium, 2004.
- [4] Mohan Manubhai Trivedi, Tarak Gandhi, Joel McCall, "Looking-In and Looking-Out of a Vehicle: Computer-Vision-Based Enhanced Vehicle Safety", IEEE Transaction on Intelligent Transportation Systems, 2007.
- [5] T Chen, Y S Chen, "Real-time approaching vehicle detection in blind-spot area", IEEE Conference on Intelligent Transportation Systems, 2004.
- [6] David P Racine, Nicholas B. Carmer and Mehrdad Hosseini Zahed, "Active Blind Spot Crash Avoidance System A Haptic Solution to Blind Spot Collisions", IEEE, 2010.
- [7] Thomas Schamm, Christoph Von Carlowitz, J Marius Zollner, "On-Road Vehicle Detection during Dusk and at Night", IEEE Intelligent Transportation Systems, 2010.
- [8] Yen-Lin Chen, Bing-Fei Wu, Hao-Yu Huang, Chung- Jui Fan, "A Real-Time Vision System for Nighttime Vehicle Detection and Traffic Surveillance", IEEE Transaction on Industrial Electronics, 2011.
- [9] Bing- Fei Wu, Chih- Chung Kao, Ying-Feng Li, Min-Yu Tsai, "A Real-Time Embedded Blind Spot Safety Assistance System", Hindawi Publishing Corporation, International Journal of Vehicle Technology, 2012.

- [10] C F Wu, C J Lin, H Y Lin, H Chung, “Adjacent Lane Detection and Lateral Vehicle Distance Measurement Using Vision-Based Neuro-Fuzzy Approaches”, Journal of Applied Research and Technology, 2013.
- [11] Being- Fei Wu, Hao-Yu Huang, Chao- Jung Chen, Ying- Han Chen, Chia- Wei Chang, Yen-Lin Chen, “A vision-based blind spot warning system for daytime and nighttime driver assistance”, Elsevier-Computers and Electrical Engineering, 2013.
- [12] Sayanan Sivaraman, Mohan Manubhai, “Looking at Vehicles on the Road: A Survey of Vision-Based Vehicle Detection, Tracking and Behaviour Analysis”, IEEE Transactions on Intelligent Transportation Systems, 2014.
- [13] Seunghwan Baek, Heungseob Kim, WooSeong Che, Duksun Yun and Kwangsuck Boo, ” A Study of Rear Side Vehicle Recognition on Curved Road by using Rear Side View Vision System”, SAE Technical Paper Series, 2013
- [14] M A Sotelo, J Barriga, D Fernandez, I Parra, J E Naranjo, M Marron, S Alvarez, M Gavilan, “ Vision-Based Blind Spot Detection Using Optical Flow”, ResearchGate, 2014.
- [15] Seunghwan Baek , Heungseob Kim ; Kwangsuck Boo, “Robust Vehicle Detection and Tracking Method for Blind Spot Detection System by using Vision Sensors”, IEEE Second World Conference on Complex Systems (WCCS), 2014 .
- [16] Yuan-Kai Wang, Shao-Hua Chen, “A Robust Vehicle Detection Approach”, ResearchGate, 2014.
- [17] Kyeong- Hoon Jung, Kang Yi, “Determination of Moving Direction by the Pose Transition of Vehicle in Blind Spot Area”, IEEE International Symposium on Consumer Electronics, 2015.
- [18] Damien Dooley, Brian McGinley, Ciarán Hughes, Liam Kilmartin, Edward Jones, Martin Glavin, “A Blind-Zone Detection Method Using a Rear-Mounted Fisheye Camera With Combination of Vehicle Detection Methods”, IEEE Intelligent Transportation Systems, 2016.
- [19] Seon-Geol Kim, Jai-Eun Kim, Kang Yi and Kyeong-Hoon Jung, “Detection and Tracking of Overtaking Vehicle in Blind Spot Area at Night Time”, IEEE International Conference on Consumer Electronics, 2017.
- [20] <http://www.volvogroup.com/content/dam/volvo/volvo-group/markets/global/en-en/about-us/traffic-safety/Safety-report-170627.pdf>.
- [21] https://e2e.ti.com/blogs_/b/behind_the_wheel/posts/advanced-safety-and-driver-assistance-systems-paves-the-way-to-autonomous-driving
- [22] L. Ye, T. Yamamoto, Impact of dedicated lanes for connected and autonomous vehicle on traffic flow throughput. Phys. A Stat. Mech. Appl. 512(15), 588–597 (2018)
- [23] GuoKu Jia and BeiChen Ding and MengTang Li, Automatic Traffic Safety Alert System for Pedestrians, 250-259, CICTP 2022, doi 10.1061/9780784484265.024.