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Role of Human Factors in the Design of Blind Spot Detection Technology

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Abstract - *Several cases of road accidents have been accounted in the past and have been investigated. The root cause of have been investigated in various cases of accidents like direct collision, driver negligence, component failure etc. and technologies have been developed to counter these conditions. Automotive companies have come up with technologies which predict an object, person or a vehicle in the Blind Spot Zone of the car. They give an indication to the driver and prevents lane shift. But certain technologies have limitations like driver override where objects like road block cones or railings have been identified in the blind spot zone and the driver can override the blind spot function and initiate lane shift. Sometimes due to the negligence of the driver, he/she fails to pay attention to the blind spot system warning and initiates lane shift and thus leads to accident. In this project, we are investigating the role of human factors which positively contributes to design of blind spot detection systems.*

***Key Words*: Blind Spot Detection, Human Factors, Anthropometry.**

1. INTRODUCTION

Blind spot is a portion of road area which is invisible to the driver. Based on the seating position and mirror alignments a certain portion behind the car is completely invisible to the driver. Any vehicle travelling in this area is under major threat since its presence is completely unknown to the preceding vehicles. Any lane shift maneuvers by the preceding vehicles leads to collision. This region is different on both the sides because of the driver' seating position and mirror orientation. According to NHTSA report [1] 207,000 crashes have occurred during lane change. Several remedies like wide angle mirrors, alarming systems etc. have been introduced but in most cases, accidents occur due to driver's negligence. The negligence of the driver can be due to various factors and sometimes the lane shift leads to a series of multiple car collision.

1.1 Background Study

1.2 Definition of Blind Spot Region

It is the region behind the vehicle which is invisible to the driver in from the driver's binocular view. The region which is not visible to the driver due to the A pillar is also termed as a blind spot but is currently neglected since it is out of scope of this paper. The demarcation of the blind spot zone is explained below.

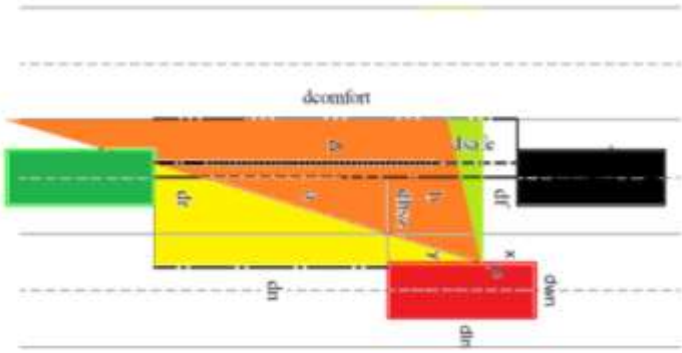

Fig -1: Blind Spot Region around the host vehicle on a freeway.

The ego, rear and preceding vehicle is shown by red, green and black respectively. The yellow region is the visible region which can be seen through the side view mirrors. The light green region can be seen from the peripheral vision and the orange region is the actual blind spot region which is not visible to the driver. If the rear green vehicle enters the orange region, it will not be visible and in an event of lane shift of the red ego vehicle to the left lane, will result in a collision.

To prevent this, a sensor based safety system was created which is called Blind Spot Detection System. It identifies the presence of vehicle in the blind spot and alerts the driver through a haptic, auditory or visual signal.

2. EVOLUTION OF BLIND SPOT DETECTION SYSTEM

There have been several technologies developed by various car manufacturers. They had a common goal to predict presence or a vehicle in the blind spot zone but each company had their own way of detection and alarming. The issue of blind spot was first addressed by George Platzer in the year 1995 [2].

This paper dealt with deriving and expressing the blind spot zone as per the laws of optics and mirror reflections. The blind zone was defined in terms of viewing angles, obstructions to vision, perceptibility limitations, and lateral separation of vehicles. Various strategies for overcoming the blind zones were discussed. Interestingly a basic primitive remedy [3] was provided by George Platzer himself in the form of wide angle mirror. In 1995, Hyland. W [4] also addressed the numerous parameters must be considered to develop blind spot detection systems.

Since the introduction of blind spot detection, car manufacturers have tried experimenting with sensor driven technologies to sense and detect vehicles in the blind spot zone. First commercially implemented blind spot monitoring system was BLIS introduced by Volvo on S80 Sedan [5]. This system gives a visual warning on the side view mirror about the presence of another vehicle in the blind spot zone. Volvo evolved and integrated Steer Assist with BLIS which steers back the vehicle into its original lane if the driver tries to shift in presence of a vehicle in the blind spot zone. This system is active at speeds between 37-87 mph.

Another feature called Cross traffic alert (CTA) was also integrated to detect vehicles crossing behind the car while reverse parking. Another interesting system was made Mercedes in 2007 came up with Active Blind Spot Assist [6]. It uses radar to sense vehicles entering the blind spot zone. It warns with a visual signal on side view mirror. If lane change is initiated, the system performs an evasive maneuver by applying brakes in the opposite wheels and keeps the vehicle in the same lane. This maneuver can be performed at speed range between 30 – 200 kmph. Ever since then every company has been experimenting with Blind Spot detection technology. They either came up with vibrating steering [BMW paper] to warn the driver or an evasive maneuver to prevent lane shift. But this sudden action might lead to instability while driving in adverse weather conditions.

Out of 207,000 accidents during lane when two vehicles are on a highway and one intentionally changes lanes, and collides with other vehicle. As per NHTSA's report on Analysis of Lane Change Crashes [7], 11.2% of the vehicles belong to the light vehicle category. This poses a high risk for the majority of the population on road. One major reason for this category of accidents is the negligence of vehicle in the blind spot region. Geometrically this region is not within the reach of the driver. So we have sensor based systems which determine the presence of vehicle. But a major threat is a situation where the driver fails to determine the presence of the vehicle in the blind spot and performs a lane shift maneuver. To assess this, in this paper we have solely focused and projected the issues related to this blind spot detection from human ergonomics point of view.

3. TAXONOMY AND CATEGORIZATION OF ISSUES

In spite of tremendous development in modern day electronics, the blind spot detection systems made by car manufacturers still pose a lot of unsolved issues which are needed to be addressed in order to make a completely fail-proof system.

For this benchmarking shown in table 1, we have taken few blind spot detection systems made by reputed car manufacturers and compared them on the basis of safety, usability and reliability related aspects. This table consists of all the major manufacturers which have introduced their version of blind spot detection and monitoring system. Over the years, manufacturers have introduced different types of features like detection during parking, lane shift assistance etc. All those have also been taken into account.

Here the basis of this study is not just to assess the development of blind spot detection systems over the years, but also to see the extent to which the manufacturers have applied the blind spot detection technology in various driving applications.

Sl. No	Company	Year	Side View Mirror Signal	Vibrating Steering	Integrated Lane Shift Assist	Blind spot warning during Parking
1	Volvo	2003	Yes	–	Yes	Yes
2	Mercedes	2007	Yes	–	Yes	–
3	Mazda	2008	Yes	–	–	–
4	Ford	2009	Yes	–	–	Yes
5	Nissan	2010	Yes	–	Yes	Yes
7	BMW	2016	Yes	Yes	Yes	Yes

Table -1: Benchmarking of Blind Spot Technologies

4. PROS AND CONS ANALYSIS

4.1 Pros of Existing Blind Spot Detection Systems

As we deduce the results, we observe that majority of the systems which have been introduced in the recent years have are advanced functions like Integrated Lane Shift Assist, which provides assistance while lane shifting. Another good feature which has been integrated with Blind Spot Detection Technology is Blind Spot Intervention system. This prevents the vehicle from lane shifting in the lane which has a vehicle in the blind spot zone. The braked on the other side of the vehicle are applied to provide a yawing action which helps to bring the vehicle back on the initial track. Another good feature is the parking assist. This helps the driver detect vehicles in the blind spot zone and hence initiate safe parking operation. Even though these systems have good capabilities to function in various environments, they too have their pros and cons.

4.2 Cons of Existing Blind Spot Detection Systems

Side View Mirror Notification.

The indication of the presence of a vehicle in the blind spot zone is displayed on the side view mirror. This is either displayed with a yellow light at the end of the mirror. This light blinks with a beep sound in the cabin. But in case of heavy rain, the accumulation of water droplets on the mirror and glass window causes difficulty in perceiving the warning signal. Also during night driving, the light from the rear vehicle is projected on the side view mirror and due to this, the blind spot signal is not clearly visible to the driver.

Radar or Camera Malfunction during Adverse weather conditions

The radar is the primary sensing device in blind spot detection systems. They provide high degree of accuracy and range in all weather conditions. But they are unreliable since they blindly detect the presence of an object in the blind spot zone such as tree, pillars of bridge etc. The optical method of sensing involves camera which is cheap and simple to install. Using image processing and AI techniques, the type of object can also be easily determined and categorized. But the major problem with cameras is that they cannot function if the lens is covered with dirt or snow and also the measurement range is small.

Blind spot detection during parking.

The blind spot detection systems are known to perform under driving conditions but they can also function during parking. Here lies multiple issues during its parking operation. If the system is radar based, then the system will not be able to correctly identify the difference between a car, person or a pillar. Also if the system is camera based, the image processing from a single camera in closed and confined spaces will lead to distorted images and will affect the object identification [8].

5. IMPLICATIONS IN TERMS OF HUMAN FACTORS IN VEHICLE

Driver also needs to accustom oneself to these systems so as to avoid the possibility of failure of these systems leading to accidents. To address these issues from an ergonomics point of view, we need to get into the depths of the system and understand its integration with the driver. This not only gives us the perspective about the human-machine interaction but also creates an iterative loop which should be refined to build better systems.

The following are the issues related to blind spot detection systems from human factors point of view. We have also listed the implications in terms of principles of design; by adapting the content from Wickens (2017) [9] and extending our analysis on implications of blind-spot detection technology in the human factors arena that could impact the design considerations of manufacturers.

Declining driver focus

Due to mental and physical fatigue, the driving abilities and concentration of the driver is affected. This causes the driver to lose focus and miss out on the important signals. Also disturbances like usage of mobile phone, talking to fellow passenger etc. decreases the focus of the driver. This lack of focus leads to inefficient vehicle operation and take decisions which are not safe. This problem becomes even worse when the weather is foggy, snowy or rainy. In these adverse weather conditions the risk percentage increases and the vehicle is more prone to instability.

Lack of exposure to technology

Drivers who belong to old age group or who are new to the modern generation vehicles might have difficulty in understanding the operation of blind spot detection system. This again creates a risky situation where the driver is totally unaware about the presence of vehicle in the driver's blind spot zone. To resolve this, the driver must be well versed with the technology and proper training should be given to understand its operation.

Negligence and Incorrect Perception of Warning Signals

Sometimes during heavy traffic or some other distraction, the driver might miss out the warning signal given by the blind spot detection system. This pure negligence of signals puts the driver in great danger. This sometimes leads to a situation which is irreversible and also not safe for the other vehicles on road.

Display of Relevant Information

The dashboard of the modern day cars are fitted with numerous switches and indicators which lead to confusion. Also when multiple signals are projected, the driver might miss out the blind spot warning signal and this leads to accidents. A simplified console is a possible solution but for the level of risk which blind spot carries with itself, there should be alternate solutions which are presented in this paper.

Overdependence on technology

In May 2016, the famous Tesla crash [10] shook the world where the Model S collided with 18 wheel trailer truck on highway. The system failed to recognize the trailer truck and took a lane shift action which led to collision. This incident posed major questions on the reliability of autonomous driving.

Similar situation can arise with the blind spot detection system. Hence, until and unless the technology is not mature enough or developed to operate safely in any environment, overdependence on the technology should be avoided and the vehicle control should be with the driver at all times.

Inaccessibility due to Physical Disability

Any visual related disability which includes partial corneal blindness, retinal blind spot, cataract etc. leads to a situation where the driver's partial vision loss leads to missing out important warning signals and hence this increases the risk percentage.

Especially in case of Bitemporal hemianopsia where the peripheral vision is affected by blindness and hence leads to complete blockage of signal which is flashed on the side view mirror.

6. PERCEPTUAL PRINCIPLES

Avoid absolute judgement limits

The alert system shouldn't burden the judgement of the divers. There should be no assumptions made on the driver's level of perception of the signal issued. For instance, if a flashing signal is presented in the top corner of the mirror in order to alert the driver of a fast approaching vehicle, it should not be assumed that the driver would perceive the signal as more urgent if the frequency of flashes increases – in other words we cannot make an assumption or require the driver to associate urgency with the frequency of flashes. Instead, provide a change of color of the flashing signal from amber to red to emphasize the urgency.

Key consideration: Does the display stress the ability of people to judge the information being presented?

Exploit redundancy gain

There is a higher possibility of perceiving the signal if the signal is displayed more than once. There are situations where the navigation panel may not be in full use, for instance, while driving long distances on a straight road or when the driver does not use the navigation system because the path is a routine one where no further help in navigation is needed.

In such scenarios, instead of displaying a map, the panel could be used to show neighboring traffic in a simple 2-dimensional fashion. This redundancy would help perception of other blind-spot related warnings in a much better way.

Key consideration: Is important information presented or communicated by more than one mode?

7. EXPECTATION IN NEAR FUTURE

Regulations

Blind spot detection is nowadays one of the features that almost every car has, either optional or, for higher class cars, already included [11]. It was used for the first time by Volvo in 2007 and it was sending a visible alert to the driver if the driver was trying to switch the lane while a car was in the blind spot.

The concept is the same now, but there are some more features introduced later, for example, the system can act on the steering wheel and apply a force that keep the car in the lane, interacting also with the line assist system.

The blind spot detection is a safety features that prevented a lot of accidents since its invention and it will most probably be mandatory for every car in the near future, like the article from "The globe and mail" says: a lot of accidents happen because of the blind spot, and the bigger the car, the bigger the blind spot.

It is reported that about 840,000 accidents are reported for the blind spot every year in United States. There are no regulations that require blind spot detection in United States, but the NHTSA, the National Highway Traffic Safety Administration, is trying to have this feature as mandatory for every car, so eventually, in the near future, we will have this feature in every new car.

Future of the automotive

For the NHTSA, in the near future, cars will be Partially Automated until 2025 and fully automated [12] from the 2025, the partial automation implies some features like the "lane keeping assist", this system works with the "blind spot detection" system in order to help the driver to keep the lane and not change it in case there is a car in the other lane, making the maneuver dangerous. The blind spot detection, also for this reason, is become more and more important and used in the new cars. In the near future, more and more cars will have these and other automated functions that of course will bring improvement at a safety level, but also efficiency and convenience, because automated vehicles would keep the traffic smoother and avoid traffic congestion.

8. FUTURE STUDY SUGGESTIONS

After carrying out the literature review, we found that future studies could focus their efforts broadly in the areas of Human Machine Interaction, Software and Hardware Platforms, Design and Testing of Algorithms and Dynamic Road and Traffic Conditions.

1. Dynamic Road and Traffic Conditions

   For instance, let us say it is the case of dealing with Large Goods Vehicles in Blind Spots. In this case the way in which Large Goods Vehicles are dealt with could be an entire different scenario than small to medium sized vehicles. If the feature of automatic speed acceleration is used in order to not have any vehicle in the blind-spot area, there is a need to accelerate the vehicle and cover a significant distance before overtaking a larger trailer in the adjacent lane. Yet, in other situations, it could be beneficial to slow down, switch to a farther lane from the trailer and then try passing the vehicle. Acceleration, deceleration or lane-change followed by either of the two, might sound like a simple if-else decision but this could quickly get complicated with the presence of other vehicles on the road, road conditions, weather conditions, human overrides etc.

2. Software and Hardware Platforms

   Integration of the aspects of Blind Spot technology in the context of higher level of autonomous vehicles requires heavy dependency on the sensors -- camera, Light Detection and Ranging (LiDAR), millimeter-wave radar (MWR), and the global navigation satellite system (GNSS). It is a widely recognized challenge that the weather conditions and low-visibility situations casue hindrances to the functioning of camera and LiDAR inconvenient. While the neighboring objects and their state of movement could be detected by the use of Millimeter-wave radar, it is difficult to comprehend the type and size of surrounding vehicles. Through literature review we found that such a technology that uses a fusion of these sensors is feasible and thus is also a viable direction of future study.

REFERENCES

1. Forkenbrock, G., Hoover, R. L., Gerdus, E., Van Buskirk, T. R., & Heitz, M. (2014, July). Blind spot monitoring in light vehicles — System performance. (Report No. DOT HS 812 045). Washington, DC: National Highway Traffic Safety Administration.

2. Platzer, G., "The Geometry of Automotive Rearview Mirrors - Why Blind Zones Exist and Strategies to Overcome them," SAE Technical Paper 950601, 1995, https://doi.org/10.4271/950601.

3. George Platzer, inventor; Compound automotive rearview mirror. U.S. Patent 20060268440 filed August 10, 2006, and issued November 30, 2006.

4. Hyland, W., "Blind Spot Systems - Design Issues," SAE Technical Paper 952618, 1995, https://doi.org/10.4271/952618.

5. Country Hill Motors. Retrieved from https://www.countryhill.com/a-used-volvo-s80-will-transform-your-driving-experience/

6. Mercedes Active Blind Spot Assist. Retrieved from https://media.daimler.com/marsMediaSite/en/instance/ko/Blind-Spot-Assist-Radar-sensors-monitor-the-areas-directly-alongside-and-behind-the-car.xhtml?oid=9361526

7. Howe, G., Xu, G., Hoover, R., Elsasser, D., & Barickman, F. (2016, November). Commercial connected vehicle test procedure development and test results – Blind spot warning/Lane change warning (Report No. DOT HS 812 317). Washington, DC: National Highway Traffic Safety Administration.

8. Alizadeh P, (2015). Object Distance Measurement Using a Single Camera for Robotic Application. (Published). Laurentian University, Ontario, Canada.

9. Lee, J. D., Wickens, C. D., Liu, Y., & Boyle, L. N. (2017). Designing for people: An introduction to human factors engineering. CreateSpace.

10. National Transportation Safety Board. 2017. Collision Between a Car Operating With Automated Vehicle Control Systems and a Tractor-Semitrailer Truck Near Williston, Florida, May 7, 2016. Highway Accident Report NTSB/HAR-17/02. Washington, DC.

11. Explaining tech: Blind-spot detection. Retrieved from https://www.theglobeandmail.com/drive/culture/article-explaining-tech-blind-spot-detection/

12. Self-driving cars, robots: Identifying AI 'blind spots'. Retrieved from https://www.sciencedaily.com/releases/2019/01/190125094230.htm

13. Automated Vehicles for Safety. Retrieved from

    https://www.nhtsa.gov/technology-innovation/automated-vehicles-safety

14. Microsoft and MIT can detect AI 'blind spots' in self-driving cars. Retrieved from https://www.engadget.com/2019/01/27/microsoft-and-mit-ai-blind-spots/

15. Finding the ‘blind spots’ in autonomous vehicle artificial intelligence. Retrieved from

    https://www.digitaltrends.com/cars/blind-spots-autonomous-vehicles/