Quantification and Analysis of Blindspots for Light Motor Vehicles

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Abstract: ***In recent years, the rapidly increasing vehicular population, deteriorating road conditions, driving environment and human factors has led to a lot of traffic accidents and casualties. If, there exist a mechanism to detect obstructions in the road, and then relay the processed information back to the driver, he may be alerted about the impending danger. The lack of visual stimuli due to blind spots, both vehicular and external is often a leading contributor of road accidents. This paper outlines procedures for calculating and analyzing the factors affecting blind spots for light motor vehicles by quantifying blind spot of the test vehicle with respect to suitable parameters. An opinion survey was conducted to understand driver needs and various opinions were collected and analyzed. An ultrasonic sensor system was developed with the collected blind spot data which maps physical environment around the car, with special care given to blind spots and relay it back to the driver in real time.***

Index Terms: Arduino, Blindspot, Ultrasonic sensor.

I. INTRODUCTION

Road accidents, which are normally not forecasted and avoidable, are general risks in day to day life. Statistics reveal that inadequate visual data is one of the major reasons for the increasing number of road accidents. Drivers are being involved in accidents, with other vehicles which are not exactly due to his/her faults, but due to the presence of certain hidden areas around the vehicle in which the driver has no visibility. These hidden areas around the vehicle are known as blind spots. Blind spot is an obscuration of the visual field, they are associated with vision as well as in vehicles. With respect to a vehicle, a blind spot is that area around the vehicle that cannot be directly observed by the driver while at the controls, under normal driving conditions either directly or through any of the mirrors. The issue whether an object is visible to a driver depends on many variables, the basic one being line-of-sight, or in other words, is the object geometrically visible to the driver with no obstructions getting in the way [1]. Various vehicular and human characteristics also affect blind spots. These factors include passenger height, age, A and B pillar geometries etc. Fig. 1.1 shows the location of two cars on the road, the driver's view from side and rear mirror highlighting the issue of blind spot.

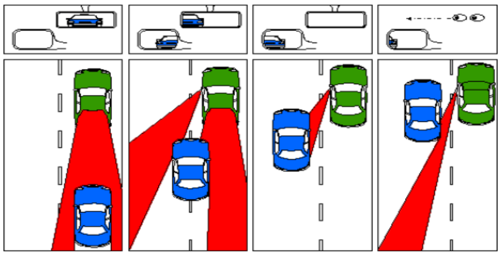

Fig. 1.1: Example of vehicular blind spot. [2]

It is necessary to monitor blind spot areas and the obstacles in the area need to be detected and reported to the driver in real time. Drivers nowadays are getting more and more concerned about safety and safety features in their cars and are also willing to pay the cost of acquiring safer vehicles and such safety equipment [3].Blind spots can be monitored using technologies of two different categories which are Active and Passive Blind Spot Monitoring. Active blind spot monitoring uses cameras and radars for monitoring whereas passive blind spot monitoring uses convex mirrors or lenses for obtaining a wider view of the surrounding. Conducting a proper study on vehicular blind spot and developing a proper blind spot detection system can bring down the accidents caused due to driver negligence in this regard.

OBJECTIVE

i. To prepare baseline for vehicular blind spots in LMV's of leading categories and use it for further studies
ii. To conduct a user opinion survey to collect data on various human factors affecting blind spots
iii. To analyze the collected data and bring out the causes and to suggest remedies to prevent accidents due to blind spots
iv. To develop a cost-effective sensor to detect blind spots and relay the information back to the driver

LITERATURE REVIEW

Kula Sekhar A. et.al. [4] developed a method for detecting blind spot by using ultrasonic sensor and controlling the direction of car by automatic steering by providing partial braking to the individual wheels and reported that the accidents caused due to driver negligence while overtaking and lane changing can be brought down by a great extent. Tigadi A et.al. [5] proposes a driver assistance system to improve a driver's safety while changing lanes on the highway in intelligent vehicle applications which uses radar based technology and camera
based technology.

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Hassan M. et.al. [6] developed a blind spot system known as ZRT Vehicle Blind Spot System (ZRT-VBSS) using Arduino and ultrasonic sensors to overcome the problems due to blind spot which is capable to detect a moving vehicle in blind spot area under static and dynamic conditions. The results from the investigation show that ZRT-VBSS is capable to perform at various operating condition that make it reliable to provide solution for driver to overcome the blind spot phenomenon.

II. Methodology

A test vehicle which is significant, relevant and one which caters to a large number of people is to be selected. The study population consisted of a spectrum of drivers with characteristics such as age, gender, driving experience and physical structure. The strategy for data collection was adopted based on this. A sample selection tree has been developed based on the above-mentioned population characteristics. Subject wise categorization of sample has been done, in which age, gender, physical characteristics and driving experience was considered. The actual and theoretical blind spots of test vehicle was identified and the actual spectrum is to be mapped above theoretical spectrum for comparison.

III. Data Collection

Selection of Test Subject and Vehicle

Maruti Suzuki Alto was selected as the test vehicle based on the monthly sales data as of November 2017, as it emerged as the Best Selling Car. Then the number of subjects to be tested for blind spots around the vehicle was fixed as 50, after considering various factors such as time taken to complete the test for a person and whether it can effectively accommodate the heterogeneity of the actual population of drivers (age and gender).Data was collected from Regional Transport Office(R.T.O), Thiruvananthapuram, Kerala regarding the number of Active Light Motor Vehicle Licensees in the region, age and gender-wise split up of the population was also obtained. The sample population was stratified in such a way that the percentage of people of various categories were kept as same as that obtained from the R.T.O data to obtain the most accurate result as shown in Fig 3.1.

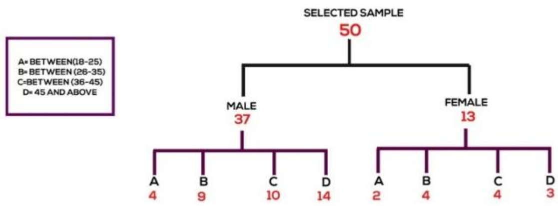

Fig 3.1: Strategy of data collection.

Identification of Practical Blind Spots

To identify the practical blind spots, initially a 2m boundary around the car was cleared and arrows were erected at the same distance around the car. A Total station was setup at a position where the car and the driver is visible. The test subject, that is drivers of different age categories was seated on the driver's seat and was instructed to adjust the seat and the mirrors as per requirement to simulate actual driving conditions. He/she was told to observe the reflective prism that one of the team member was moving with along the 2m boundary and was instructed to acknowledge when the prism was not visible to him. Driver's response was recorded and area around the car which was not visible to the subject was marked on the ground and reading was taken with the Total Station. The Subject's eye position was also measured with the prism kept at the subjects' eye level.

The points plotted in site using the total station was opened in AutoCAD software. The respective angles subtended by the blind spot regions at the eye of the driver was noted, added and expressed as a percentage. Fig 3.2 shows schematic representation of the theoretical blind spot of the vehicle.

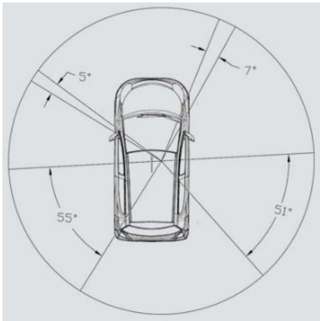

Fig 3.2 Schematic representation of the practical blind spot around a vehicle.

Identification of Theoretical Blind Spots

The theoretical blind spots are those caused by the geometric design of the test vehicle around the vehicle which is independent of various human characteristics. A powerful laser pointer kept at 120cm from ground level was used to replace the test subject to provide data that are independent of human factors and the data collection was finished as per the previous method.

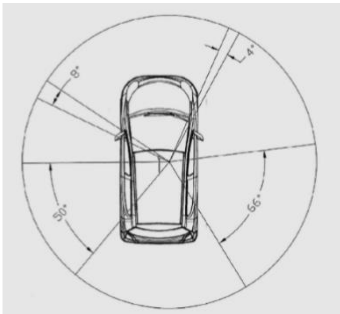

Fig 3.3 Schematic representation of the theoretical blind spot around a vehicle

Questionnaire Survey

A questionnaire survey was prepared using questions regarding awareness of blind spot. Responses to the survey questions were recorded and suggestion towards blind spot reduction according to them was also noted.

IV. Data Analysis

The primary results of the collected data is described below:

A. Variation in age wise classification

The percentage blind spots for each of the selected age category are observed as:

- for age group A (18-25), the observed percentage blind spot was 30.41%
- for age group B (26-35), it was 31.64%
- for age group C (36-45), it was 32.6%
- for age group D (>45), it was 33.74%

It is clear from the obtained data that age and blind spot percentage has a directly proportional relationship.

B. Variation in height wise classification

The percentage blind spots for each of the selected height category are observed as:

- for height, up to 160cm, the observed percentage blind spot was 32.06%
- for height between 161-170 cm, it was 33.84%
- for height >170cm, it was 30.57%

It was observed that there is an increase in the percentage blind spot up to 170cm and then this trend began to decrease as height further increased.

C. Variation in gender wise classification

The percentage blind spots for males and females of the selected age category are observed as:

- for age group 18-25 years, blind spots were 28.75% for males and 33.75% for females
- for age group 26-35 years, blind spots were 31.35% for males and 32.29% for females
- for age group 36-45 years, blind spots were 33.11% for males and 33.31% for females
- for age group >45 years, blind spots were 34.01% for males and 32.03% for females

It can be concluded that females had higher degree of blind spots for ages up to45 years and the trend reversed contrary to what was expected for ages greater than 45 when compared to male counterparts.

V. Discussion of Test Results Based on Collected Data and Questionnaire Survey

Discussion based on human characteristics.

The outcomes of the study of blind-spots with respect to person's physical character are discussed below.

a) Age:

As expected, blind spots were found maximum in age category D i.e. greater than 45, and in youngster's blind spots were comparatively lower than older counterparts. This can be accounted by a fact that as the age of a person increases, the ability of the ciliary muscles which controls our pupil size to function effectively decrease which causes reduction in sight. Peripheral vision also deteriorates as a person ages leading to increased blind spots around the car.

b) Gender

It is seen that female drivers have higher percentage of blind spots than their male counterparts. Such a variation based on gender might be due to increased peripheral vision in men which is contrary to popular belief that women has higher peripheral vision. However, in female drivers aged above 45, a slight variation in this trend was observed as percentage blind spots for male drivers were more than female drivers. The result obtained might not be an actual representation of the true data as number of test subjects were 3 and a conclusive statement can only be made after conducting further test.

c) Corrected vision

Drivers using spectacles, even though have corrected vision was found to have ahigher percentage blind spot as most of the such drivers complained of the blocking of view by the spectacle frame, which can be the reason.

d) Height

The variation of percentage blind spot with height of the person was similar to that of a bell curve i.e. the percentage blind spot was low for height up to 160cm and for height greater than 170cm in general. However, for drivers having height in between 160-170cm the data clearly shows an increased blind spot percentage.

e) Vehicle

The geometric design of car determines to a large extend the degree of blind spot in the vehicle. It is generally accepted that the degree of blind spot and size of the vehicle under consideration follows a directly proportional relationship.

Comparison of Average Blind spot with Theoretical Blind spot

The average value of degree of blind spot around the vehicle after taking into consideration the values obtained from 50 test subjects was 116^0 which was very much similar to the obtained degree of theoretical blind spot which was 118^0.This similarity between the obtained values and theoretical values indicates a geometric similarity in design of the vehicle that suits to the need of the drivers.

VI. Model Development

Effective blind spot monitoring can only be achieved by providing a complete 360ºcoverage using sensors and cameras around the vehicle. It's very helpful to the drivers, if he is able to view the obstacles around his car while at the controls in an effective and economic manner. The system can reduce the number of accidents and causalities by a huge amount and provide a proper assistance to the driver in his or her blind spots. A model based on the concept studied has been prototyped in the form of a deviceincorporating ultrasonic sensors, Arduino mega microprocessors, power supply boards, vibration motor, etc. which can provide a complete 360º coverage around the vehicle.

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WORKING

Two ultrasonic sensors were used at right and left side of the car. These sensors were rotated at 180^0 using a servo motor to achieve a complete 360^0 coverage around the car. In actual case, more number of sensors can be accommodated around the vehicle, which can eliminate the use of servo motors. Ultrasonic sensors emit ultrasonic radiations, these radiations propagate through the medium strike the obstacle and reflect back to the sensors. Receiver captures the signal and transfers it to Arduinomicroprocessor. Two microprocessors (Arduino Mega) were used to process the data received from the sensors. Fig 6.1 shows the arrangement of the various components.

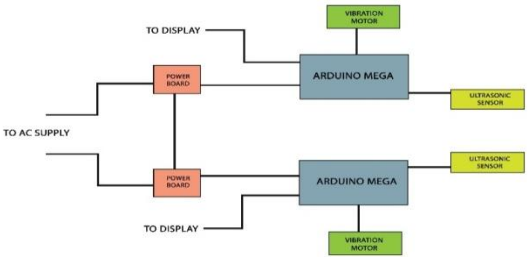
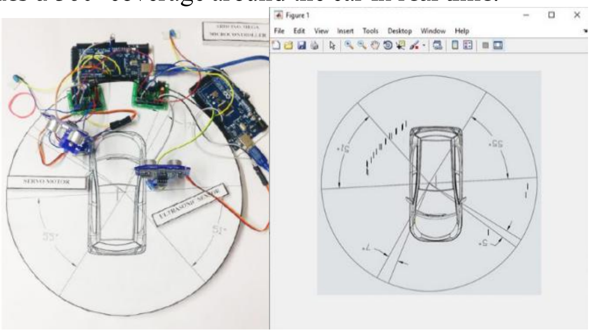


Fig 6.1: Arrangement of various components

The received data consist of the position of the obstacle and the distance between the car and the obstacle. The data is processed by the microprocessor and the processeddata was plotted on a screen using MATLAB software. Two additional power supply boards were used to power the circuit. These power circuit boards were connected to AC mains. Blind spot data of the driver obtained from the survey was transferred to the Arduino microprocessor. A vibration motor was set up to the chip to give a slight vibration to the steering wheel when there is an obstacle or a vehicle approaching through the blind spot region. The advantage of the system is that it provides a 360^0 coverage around the car in real time.



(a) (b)

Fig 6.2 (a): Photograph of the prototype developed
(b): Sample output from MATLAB

VII. CONCLUSION

The following specific conclusions can be drawn based on this study:

- There exist conical pillar shaped portions which hinders vision of drivers named as A, B and C Pillars.
- These pillars create obstruction to the visibility of drivers which depends on the design of vehicle and characteristics of the driver.
- Proper side mirror adjustment and additional fittings on side mirror can eliminate the problems occurring due to blind spot to a certain extend.
- Scientific studies on blind spots may lead to changes in vehicular manufacturing, effective placing of the pillars and reducing the area of pillars can lead to reduction in accidents related to blind spots.
- Awareness among drivers on blind spots varies with respect to their age, gender and driving experience.
- Prototype model which senses the driver's blind spots and alerts him has been developed which helps the driver to understand his/her driving behavior with respect to blind spot and act accordingly.
- Pedagogical tools such as videos and other driver training methods may help to bring in importance of this concept and make necessary changes in the driving behavior.

VIII. LIMITATIONS OF THE STUDY

The following could be pointed out as the limitations of the study.

1. The sample population was limited to 50
2. Only one car was analyzed
3. Theoretical blind spot was taken as the average of only 3 trials.
4. The number of variables accounted were limited
5. Only static conditions were observed and dynamic conditions while driving were ignored
6. Driver perception was not considered
7. Test was only carried out during day time
8. Only a single weather condition was tested
9. Physical properties of the obstructions were not considered

Different assumptions had to be made over the course of the paper such as:

1. Eye level of the driver was assumed as 1.20m for theoretical blind spot determination
2. The vehicle was assumed to be on a flat area
3. A circular area with radius 2m around the car was considered as significant for the project

IX. SCOPE FOR FURTHER STUDY

The primary objective of this project work was to determine and analyze the geometrical blind spots around light motor vehicles. Many areas of future research have arisen from the experimental work and the most significant of them are outlined below.

- The project Quantification and Analysis of Blind spots for Light Motor Vehicles can further be expanded into various categories of vehicles such as buses, trucks, and to different cars in the future.

- The data obtained from the project can be used to create a Blind Spot Detection and Awareness Sensor which can be implemented on a large scale in commercial vehicles.
- The project can be expanded for dynamic conditions also, considering the various conditions prevailing under driving.

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