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Assessing the Blind Spot Zones of Passenger Cars

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ABSTRACT – *Blind spots can still cause problems, even in circumstances where visibility is perfect and optimal for driving. Therefore, it is crucial to understand the Blind Spot Zone (BSZ), particularly its associated parameters, in order to create an effective system that is successful at detecting approaching vehicles and alerting the driver. It is also essential to understand that the size and locations of blind spots vary depending on various factors. Therefore, this study is aimed to evaluate the blind spot zones of passenger vehicles from a driver's perspective. A systematic approach using a grid-based technique is proposed to model the BSZ. An experiment was conducted using a commonly used passenger car in Malaysia with a total of 30 cars which are classified into five segments: A, B, C, D, and 4x4. Each car's BSZ area was identified, and the viewing angles of the driver were measured for both sides, driver, and passenger, respectively. As a result, the cars in segments A and B had the largest average blind spots, while the cars in segments C, D, and 4x4s had the widest viewing angles. In addition, it was found that the typical blind spot area on the passenger side is larger than the driver's side.*

KEYWORDS: Blind spot, passenger car, grid-based technique, blind spot zone, viewing angle

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1. INTRODUCTION

Blind spots are obscurations of the visual field that can occur in both eyesight and vehicles. Blind spots can be unpleasant even when sight is great and appropriate for driving. For example, the driver is unable to notice approaching vehicles, which may result in a crash while changing lanes. A Blind Spot Zone (BSZ), in the context of a vehicle, is the area around the vehicle that the driver cannot see directly or through either of the mirrors while at the controls under typical driving conditions (Mathew et al., 2018). Normally, BSZ (Figure 1) is in the areas toward the rear of the vehicle on both sides (Hashim et al., 2018).

One of the Safety Assist Technologies that can help to overcome the blind spot situation is the Blind Spot Technology (BST). BST is an Advanced Driver Assistance System (ADAS) feature that assists drivers in avoiding possible hazards (Azmi et al., 2019). Its purpose is to help the driver in maneuvering the vehicle in specific conditions. For example, BST may monitor and identify an obstacle in the driver's line of sight while driving (Isa et al., 2015).

Furthermore, BST is most effective when the equipped vehicle is passing, being passed, or preparing to make a lane change. Some systems warn when the BST sensors detect those one or more vehicles have entered either of the driver's two rear BSZs, and some warn only when other vehicles are in a driver's BSZ at a time when the vehicle turn signal is activated (Kassim et al., 2019). As a result, BST has the potential to reduce the occurrence of traffic crashes.

Several studies have been carried out to determine the BSZ, and many types of sensors have been utilized to detect approaching vehicles in the BSZ (Kassim et al., 2019). Nevertheless, there have been relatively few studies on BSZ for passenger cars, particularly on the implications of various factors such as driver height, mirror size, and vehicle size. Thus, this study evaluated the BSZs and viewing angles of the driver for passenger cars used in Malaysia.

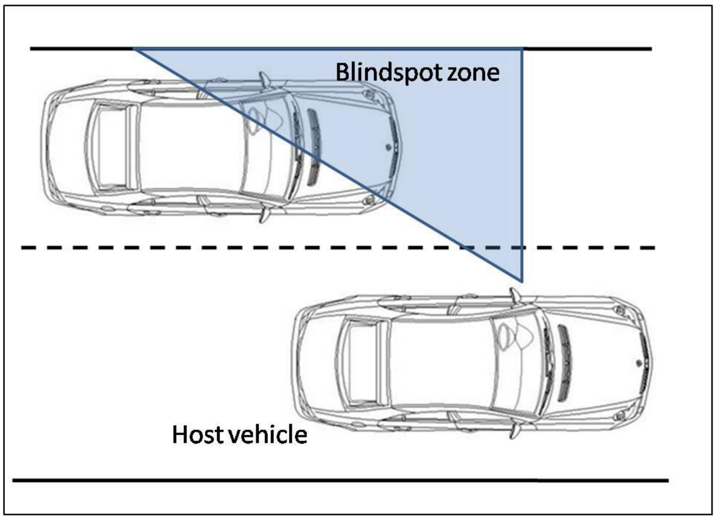

FIGURE 1: Blind Spot Zone (Saboune, 2014)

The objectives of this study are:

i. To identify the area of the blind spot zone from the driver's perspective,
ii. To determine the driver's viewing angle with respect to the different models of the car.

2. METHODOLOGY

2.1 Preparation

Three (3) main preparations must be undertaken for this study, which is as follows:

i. Vehicles used for the experiment (passenger cars and motorcycle dummy),
ii. Equipment to conduct the experiment, such as a grid of 5,000 mm x 5,000 mm, measurement tape, etc., and
iii. Experimental procedure.

Numerous models of cars, a total of 30, and a permanent male driver with a height of 1.68 meters were used in this study to determine the association between vehicle size and blind spot zone. Isa et al. (2016) anthropometric data were used as a reference in this study, specifically the average height of Malaysian male adults, which is 1,687.9 mm.

Cars are classified based on body type, size, purpose, and numerous other features in order to categorize them and make them easier to compare. To distinguish between their geometric designs, these market segments were utilized in the analysis. Segment A comes with five cars, while segments B and C have twelve and nine cars, respectively, and segments D and 4x4 have two cars each.

2.2 Blind Spot Zone (BSZ) and Viewing Angle of Driver

The blind spot zone was determined by using a grid-based modeling approach, as illustrated in Figure 2 below, with a dimension of 5,000 x 3,000 mm and each grid set to 500 x 500 mm, which was sufficient to determine the zone. The grid's dimensions are based on the ASEAN NCAP protocol, and it was positioned beginning at the driver's 95th percentile ellipse. The shaded area indicates BSZ and θ is the viewing angle of the driver.

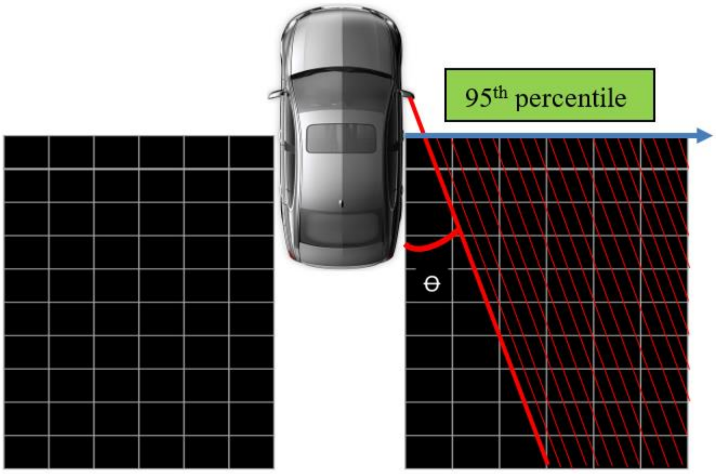

FIGURE 2: Grid-based BSZ modeling

2.3 Experimental Setup

Figure 3 shows how the experiment for this study was set up. For the first round, the data collection was collected for the driver’s side. Before the experiment began, the grid was positioned on the driver’s side as per the ASEAN NCAP protocol, and the driver was asked to adjust the driver’s seat according to his preferred position. The driver was then instructed to adjust the side mirror on the driver's side so that he could view the back side of the car comfortably.

FIGURE 3: Experimental setup in outdoor environment

2.4 Data Collection

For the data collection, two Research Assistants (RA) were instructed as follows:

i. to move the motorcycle dummy from one grid to another grid, and
ii. to record the driver’s judgment towards the visibility of the dummy.

The motorcycle dummy was moved grid by grid by the RA to measure the driver’s view from the side mirrors. The driver's judgment of the dummy's visibility was then recorded by another RA who was seated beside the driver. Each grid was marked to indicate whether the driver could see the dummy or not. In addition, the height of the side mirror and the driver’s eyes were also taken by using a measurement tape.

3. RESULTS AND DISCUSSION

The results of the experiment, which include the BSZ area and viewing angle of the driver, are reported separately for the driver's side (DS) and passenger's side (PS). The comparative results for both sides were also discussed, and the impact of a properly adjusted side mirror was also determined for this study.

3.1 Data Analysis

The results, as shown in Figure 4, were colored blue to indicate the driver's ability to see the motorcycle dummy and red to indicate the driver's inability to see the dummy. The BSZ was determined by calculating the areas plotted in red, and the driver's visibility angle was examined after the data was collected.

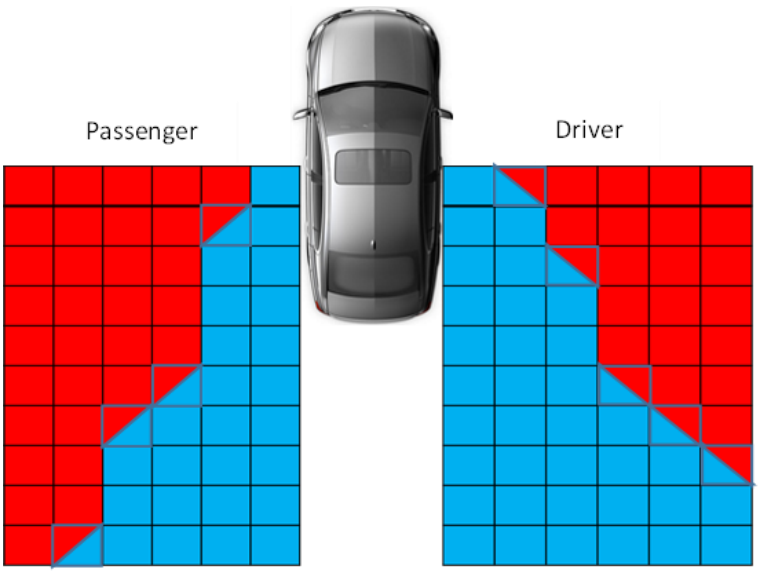

FIGURE 4: BSZ plotted with blue and red color

3.2 BSZ Area and Viewing Angle of Driver

Table 1 tabulates the distribution of blind spot areas and driver viewing angles on the driver's side, which has been separated into mean, median, and standard deviation (S.D.) for each car segment. Cars in the 4x4 segment have the smallest average blind spot area, which is 2.8 m^2 (S.D. 0.8 m^2). Meanwhile, cars in segments A and B had the largest average blind spot area, at 5.8 m^2 and 6.0 m^2, respectively.

In terms of the driver viewing angle, cars in segment 4x4 also recorded the largest angle with an average of 39.8° (S.D. 2.1°), followed by cars in segment D with an average of 39.5° (S.D. 0.7). Cars in segment B, on the other hand, had the smallest viewing angle of 33.9°.

Similarly, to that reported in Table 4, the distribution of driver viewing angles and blind spot areas on the passenger side, subdivided by mean, median, and standard deviation (S.D.), is also summarized in Table 4 for each car segment. The average blind spot area for cars in the 4x4 segment is 5.7 m^2 (S.D. 1.7 m^2), which is the lowest, while cars in segments A and B had the biggest average blind spot areas, at 7.6 m^2 and 7.8 m^2, respectively.

Besides that, all car segments recorded an average viewing angle for the driver of between 29 and 32.7 degrees, which is a very slight difference from the driver's side. The largest angle was recorded by cars in segment C, which had an average of 32.7° (S.D. 4.1°).

TABLE 1: Blind spot areas and viewing angles on the driver's side

Segment	BSZ Area, m^2				Viewing Angle, Θ (°)			
	DS		PS		DS		PS	
	Mean	S.D.	Mean	S.D.	Mean	S.D.	Mean	S.D.
A, n=5	5.8	1.1	7.6	1.0	36.2	4.3	29.6	1.4
B, n=12	6.0	0.8	7.8	1.0	33.9	2.7	28.6	3.1
C, n=9	4.3	0.5	6.8	0.8	38.6	4.6	32.7	4.1
D, n=2	3.1	0.5	6.3	1.6	39.5	0.7	32.0	0.7
4x4, n=2	2.8	0.8	5.7	1.7	39.8	2.1	29.0	2.1

3.3 Comparison between Driver and Passenger Sides

Table 2 shows the comparison result for the BSZ area and driver viewing angle according to car segments and the mean height of the driver's eyes. For all segments, the average blind spot area and angle for the driver's side were 4.4 m^2 and 37.6°, respectively, while for the passenger's side, the average blind spot area was 6.8 m^2 and the average viewing angle was 30.0°.

TABLE 2: Driver and passenger side blind spot areas and viewing angles

Segment	BSZ Area, m^2		Viewing Angle, Θ (°)	
	Driver	Passenger	Driver	Passenger
A, n=5	5.8	7.6	36.2	29.5
B, n=12	6.0	7.8	33.9	29.3
C, n=11	4.3	6.8	38.6	30.0
D, n=2	3.1	6.3	39.5	32.0
4x4, n=2	2.8	5.7	39.8	29.0
Average	4.4	6.8	37.6	30.0

The average blind spot area on the car's passenger side was discovered to be larger than the driver's side, with a difference of 2.4 m^2. In contrast, the driver's range of view on the passenger side was smaller than on the driver's side. This might be due to the design of the side mirror and its effects on the driver's viewing angle and field of view (McNelly et al., 2015). Based on the observation, the distance from the driver's eyes to the side mirror on the passenger side was larger compared to the distance from the side mirror on the driver's side. The angle adjustment of the side mirror on the passenger side, Θ_P was, therefore, smaller than on the driver's side, Θ_D as shown in Figure 5.

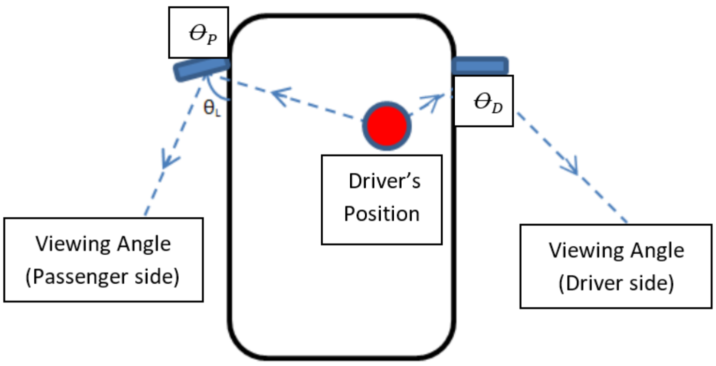

FIGURE 5: Viewing angle from the driver and passenger sides (Hashim et al., 2018)

4. CONCLUSION

In conclusion, the main goal of this study is to evaluate the blind spot zones of passenger cars from a driver's perspective. The highest average blind spot areas were found in segments A and B cars, while the widest viewing angles were found in segments C, D, and 4x4. This might be due to the variation in car body length across segments. Other combination components, such as the height of the side mirrors, the height of the driver's eyes above the ground, and others, may also have an influence on the BSZ area and the driver's viewing angle.

Besides that, the typical blind spot area on the passenger side of a car was revealed to be bigger than that on the driver's side. The average blind spot size on the passenger side of the cars was found to be bigger than on the driver's side. On the other hand, the driver's range of view on the passenger side was narrower than on the driver's side. This might be due to the side mirror's design and how it affects the driver's viewing angle and field of view. According to the findings of this study, the distance from the driver's eyes to the passenger side mirror was larger than the distance from the driver's side mirror.

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