Identifying Blind Spot Zone for Passenger Cars using Grid-Based Technique

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Identifying Blind Spot Zone for Passenger Cars using Grid-Based Technique

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Abstract – *A person driving a passenger car depends on the rear view mirror and two side-mounted mirrors to observe the surrounding in order to see vehicles approaching from behind. However, the approaching vehicle may enter a region outside the driver's field of view, making it inconspicuous to the driver. Such a region is known as the blind spot zone (BSZ). Although driving schools emphasize the importance of checking for vehicles in BSZ before attempting to change lane, many fatal collisions have occurred during lane changing. Thus, it is important to understand BSZ particularly its corresponding parameters in order to develop an effective system to detect approaching vehicles and provide warning to the driver. In this paper, 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 as a test bed to model the BSZ. Controlled experimental parameters were introduced, and the final results showed that BSZ can be identified using the grid-based technique.*

Keywords: Blind spot zone identification, grid-based technique, passenger cars

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1.0 INTRODUCTION

The blind spot zone (BSZ) is a zone around a vehicle where the driver is unable to see an object. Normally, BSZ is located in the areas toward the rear of the vehicle on both sides. The driver is unable to see approaching vehicles, which in turn, may cause an accident while the driver is changing lane. Driver visibility in relation to BSZ has often been studied as it is significant to the development of detection and warning systems. Researchers have used various methods to establish the blind spot zone. By focusing on the driver posture and restraint position of the driver's head, McNelly et al. (2015) utilized population models in order to validate Platzer's methodology for overcoming the vehicle side mirror blind spots. Their findings suggest that Platzer's methodology was able to eliminate side mirror blind spots for vehicles with a minimum length of 13 feet for 90% of the population.

Most reviews on BSZ are based on studies of commercial vehicles or heavy transport vehicles. Ball et al. (2007) studied driver visibility by using X-Y grid, with the aid of an assistant to mark visibility area. The information was then analysed using photogrammetry and 3-D computer models. In 2011, Summerskill presented the identification of blind spots in direct and indirect vision for heavy transport vehicles. He employed Digital Human Modeling (DHM) and anthropometric data of 4th percentile UK male and 99th percentile UK male. Driver posture was captured and used in DHM for determining blind spots. On the other hand, Pandian et al. (2016) proposed the use of fuzzy-based intelligent decision model to optimize the blind spots of heavy transport vehicles. In their study, several methods were used, namely ANOVA (Analysis of Variance), TOPSIS (Technique for Order of Preference by Similarity to Ideal Solution), FAHP (Fuzzy Analysis Hierarchy Process) and GRA (Grey Relational Analysis), to optimize blind spots. Several variables including driver seat design and rear view mirror design were considered to ascertain the effectiveness of the proposed model. Subsequently, the researchers were able to optimize the design parameters for blind spot reduction.

In the past few years, OEMs have introduced their own version of blind spot detection system by utilizing on-board camera, radar and ultrasonic for monitoring and detecting approaching vehicles from the left or right side of the vehicle. This led Sivaraman and Trivedi (2013) to review the recent developments of the on-road vision-based vehicle detection for passenger vehicles. In addition, most researchers use monocular and stereo-vision in order to detect approaching vehicles. Monocular vision detection relies largely on the feature extraction-classification paradigm based on machine learning and works very well when the vehicle is fully visible. On the other hand, stereo vision detection recognizes the vehicle in a bottom-up manner which consists of ego-motion compensation, tracking feature points in 3D, distinguishing static from moving points, associating moving points into moving objects and finally moving objects are labelled as vehicles by fitting a cuboid model. However, this approach is still unreliable especially in complex scenes. The most recent technology for detection uses wireless sensors, such as ultrasonic, ZigBee and milimeter wave radar. Raj et al. (2016) proposed a ZigBee-based collision avoidance system for blind spots. They tested the system in heavy traffic and the driver was alerted by a LED indication and sound buzzer. Further, Liu et al. (2017) proposed a detection and warning system using millimeter wave radar for blind spots under daytime and night time conditions. The system was integrated on the Cherry Arrizo7 and tested under various urban traffic scenes. Based on the results, the system's early alarm rate increased to 98.20% and 98.21% for daytime and night time conditions respectively.

In summary, numerous research have been conducted to determine BSZ especially for heavy transport vehicles while various types of sensors have been used to detect approaching vehicles in BSZ. However, there have been very few research on BSZ for passenger vehicles especially on the effects of various variables, such as the height of drivers and types of car. Thus, this paper shall seek to study BSZ for passenger cars as well as the effects of driver's height to BSZ.

2.0 DETERMINING BLIND SPOT ZONE

In this study, the blind spot zone (BSZ) was determined using grid-based modeling as shown in Figure 1. The shaded area indicates BSZ and θ is the angle of BSZ. Each grid was set to 500mm × 500mm. The area covered was 3500mm × 4500mm for each side of the vehicle, which was sufficient to determine the zone. The anthropometric data from Md Isa et al. (2016)

were used in this study, specifically the average height of Malaysian male adults, which is 1687.9 mm.

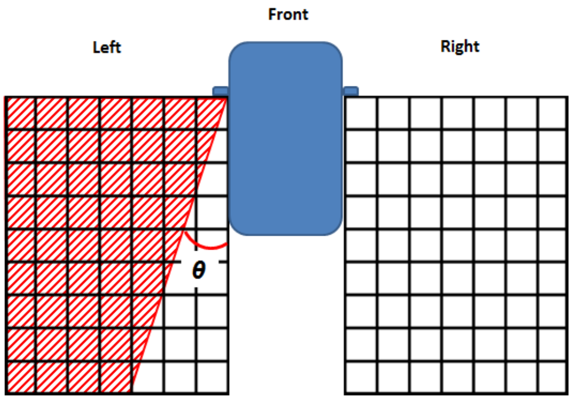

Figure 1: Grid-based modeling for BSZ

Measuring driver visibility from the side mirrors began by placing an object such as a pole, or in this case, the presence of a person, grid by grid. The driver's response on visibility of the object was then recorded. Each grid was marked to determine whether the driver can see the object. In addition, drivers of different height were employed in this study to establish the relationship between BSZ and driver's height.

2.2 Experimental Setup

In the study, only one car model from the A-segment was used to determine BSZ. The Perodua Viva was selected as it was the most popular A-segment car. Specifications of the selected car are tabulated in Table 1.

Table 1: Specifications of car used in the experiment

No.	Item	
1.	Model	Perodua Viva
2.	Length	3,575 mm (140.7 in)
3.	Weight	1,475 mm (58.1 in)
4.	Height	1,530 mm (60.2 in)
5.	Curb weight	790 kg (1,742 lb.)

The experiment was set up as in Figure 2. The grids were placed on both sides of the car. Six drivers were chosen with their height ranging from 165 to 172 cm. The drivers were instructed to adjust the driver seat according to their preferred position and to adjust the side mirrors so that they were able to see a quarter of the car body. A research assistant was instructed to move from one grid to another and the ability of the driver to spot the research assistant was then recorded.

Figure 2: Experimental setup in laboratory

3.0 RESULTS AND DISCUSSION

Results were then plotted with red colour to indicate the driver's inability to see the object (the research assistant), while green indicated the driver was able to see the object as shown in Figure 3. The summary for blind spot area and angle for every driver according to his/her height is tabulated in Table 2.

Table 2: Blind spot zone and angle for each driver

Height (cm)	BSZ area (m^2) (Left)	BSZ angle, θ (°) (Left)	BSZ area (m^2) (Right)	BSZ angle, θ (°) (Right)
165	11.25	18.4	9.50	29.1
166	11.75	18.4	11.00	18.4
167	11.75	18.4	10.00	29.1
167	11.50	18.4	10.25	29.1
171	11.25	18.4	9.50	24.0
172	10.875	24.0	9.75	29.1

The results indicate that each driver experienced almost identical blind spot zone and angle on the left and right side of the car. The average blind spot area and angle for the left side of the car were 11.40m^2 and 19.33° respectively. In addition, the average blind spot area and angle for the right side of the car were 10.00m^2 and 26.47° respectively. BSZ for the Perodua Viva is shown in Figure 4.

It was found that blind spot area on the left side of the car was larger compared to the right side, while BSZ angle of the left side was smaller than the right side. This might 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). From the observation, the distance from the driver to the left side mirror was larger than to the right side mirror. Thus, the angle adjustment of the side mirror for the left side, θ_L was smaller than the right side, θ_R. This affected the viewing angle of the driver as depicted in Figure 5.

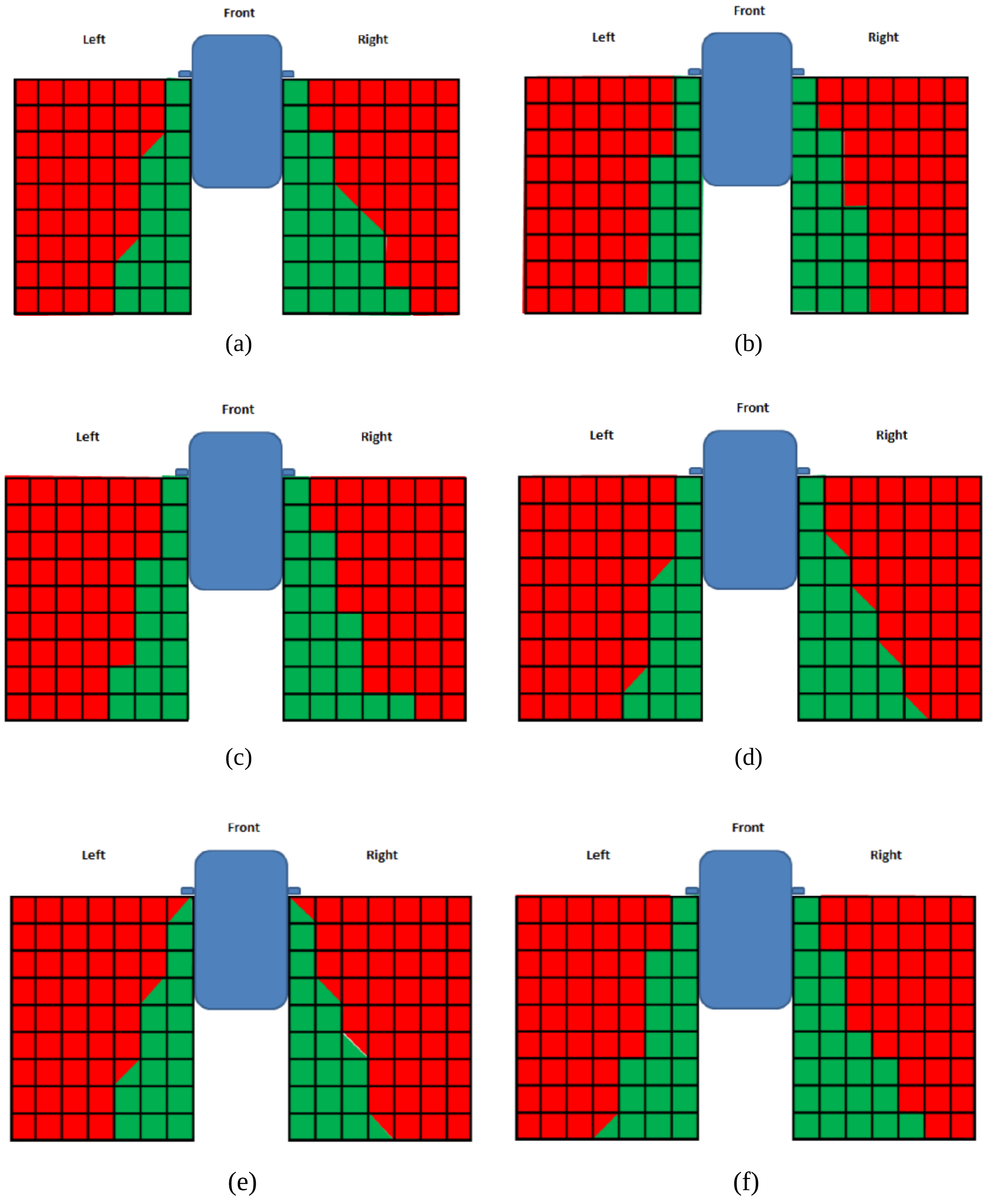

Figure 3: Plotted grid for each of the drivers' height with red indicating BSZ and green is non-BSZ. (a) 165cm; (b) 166cm; (c) 167cm; (d) 167cm; (e) 171cm; and (f) 172cm.

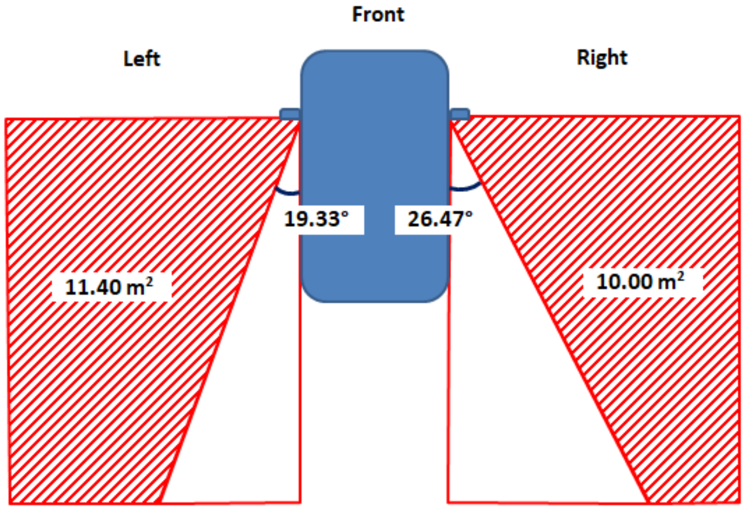

Figure 4: Blind spot zone for Perodua Viva based on grid-based technique

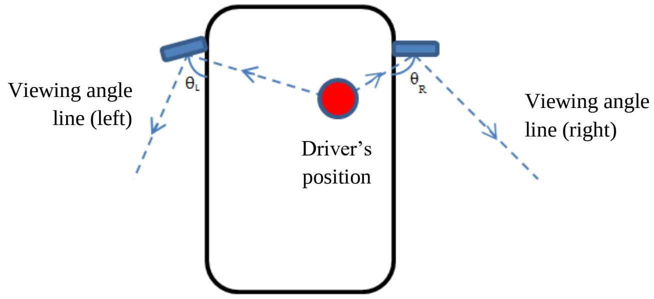

Figure 5: Viewing angle of the driver for left and side of the car

4.0 CONCLUSION

Driver visibility while using the side-mounted mirror remains the major cause of many accidents during lane changing. Therefore, establishing the blind spot zone (BSZ) and the parameters that may affect driver visibility is important to develop BSZ detection and warning systems. This study has been conducted to achieve such objectives. In the experiment, one car (Perodua Viva) with drivers of different height were used to understand the relationship between driver's height and BSZ on the left and right side of the car. However, more variables shall be included in the future, including viewing angles and the use of different car models. This is to establish BSZ for various passenger cars in the market. In addition, a camera will be used instead of volunteer drivers to collect more data sampling and to ensure consistency.

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