Study Regarding Visibility Geometry in Vehicles' Rear-View Mirrors

Alexandru Ionut Radu[1], Corneliu Cofaru[1], Bogdan Tolea[1], Daniel Dragos Trusca[1], and Horia Beles[2]

[1] Transilvania University of Brasov, Romania, [2]University of Oradea, Romania
alexandru.radu@unitbv.ro

Abstract. This paper has proposed to study the vehicle's visibility in the rear-view mirrors and how it influences driving on multilane roads. Two automotive road vehicles were studied, a small city vehicle and a much larger saloon vehicle, their visibility angles in the mirrors were measured and the blind spots were identified. Also, a simple method of correctly adjusting the mirrors is presented to reduce blind spots as much as possible.

Keywords: mirrors; vehicle; visibility; blind; spot; angle.

1 Introduction

On most modern road vehicles, there are usually installed devices that allow drivers to see indirectly other vehicles behind him. These devices are usually mirrors, mounted on the side front doors and on top on the windshield. Without mirrors, the visibility behind the vehicle is very limited and would increase the chance of road accidents when changing lanes and turning in intersections.

Other indirect devices are cameras mounted on specific areas of the vehicle that allow the driver to view blind spot areas. Such areas are under the side mirrors and in the rear of the vehicle.

The devices mentioned are most useful when traveling on multilane roads and the driver is required to change the lane. This maneuver can cause major accidents, mainly on high-speed multilane roads, as highways. These types of accidents occur frequently in Germany, being the fourth most common cause of car accidents and, in the US, they represent about 9% of the total vehicles 'accidents [1].

When attempting to make a lane change, the driver must be sure whether another vehicle is located in its blind spot position, and also the driver must appreciate a correct distance from the vehicle on the other lane [2].

The size and the shape of the wing mirrors also influence the distance perception, and the view of the rear field [3].

Mirror's visibility also depends on the very shape of the mirror; a convex mirror will provide a better visibility angle and a better perception of the distance of the vehicles on the other lanes [4].

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2 Objectives

The main objective of this paper is to study the visibility field in the vehicle's mirrors compared to different automotive models. In the case of this study, two vehicle models were used, a small hatchback and a larger saloon, vehicles belonging to different generations.

Another objective is to study the correlation between the size of vehicle's wing mirrors and the angle of visibility. This study will present if a smaller mirror will provide a smaller angle of view compared to a larger mirror.

A third objective is to study mirror visibility in the case of a traffic accident, due to blind spots, when attempting to change lanes. This is a major problem as, when attempting to change lanes, accidents occurred due to blind spots, and it is most dangerous at a high speed roads with multilane.

And finally, the paper presents the study of possibilities of reducing blind spots in mirrors. Automotive manufacturers have tried to resolve this issue, and this study will try to find possible solutions to be applied on reducing the blind spot.

3 Methods and equipment used

For this study 2 vehicles were used to measure the rear-view mirrors geometry, a compact vehicle and a mid-size saloon. The angles of mirror's visibility of these vehicles were measured.

To measure the visibility angles, the vehicles were positioned against a wall, at two meters from it, and the marks recorded on the wall were measured and labeled, beginning at the rear-center point of the vehicle and being extended to the sides of the vehicle. This is presented in figure 1.

Also, to determine the blind spots on the side of the vehicles, they were positioned on a two-lane road, next to each other and in the same direction, at the point at which, on one of the vehicle's mirror, the other one was not visible, the distances were measured. In this measurement a solution to eliminate blind spots was used and verified.

Equipment used was a basic measure tape, cameras positioned on the mirrors and a laser measurer.

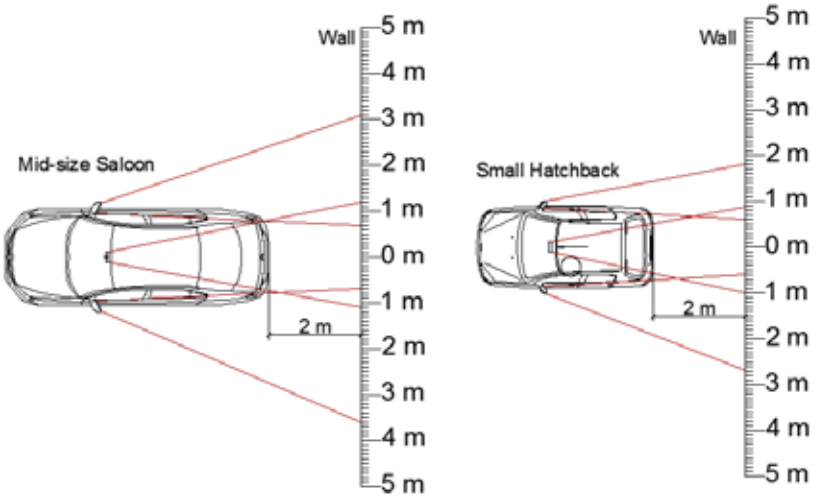

Fig. 1. Method of measuring mirror's angles

To measure the blind spot, the scenario is presented in figure 2. The vehicle in which the mirrors were verified was positioned at 0.3 meters from the center lane line and the other vehicle at the distance of 1 meter. The reason why the second vehicle is positioned at that distance is to take into account the worst possible visibility, when the blind spot is maximum. The lane taken into account as the standard had 3.5 meters wide. The green line represents the driver's view, meaning it is easily visible to him/her.

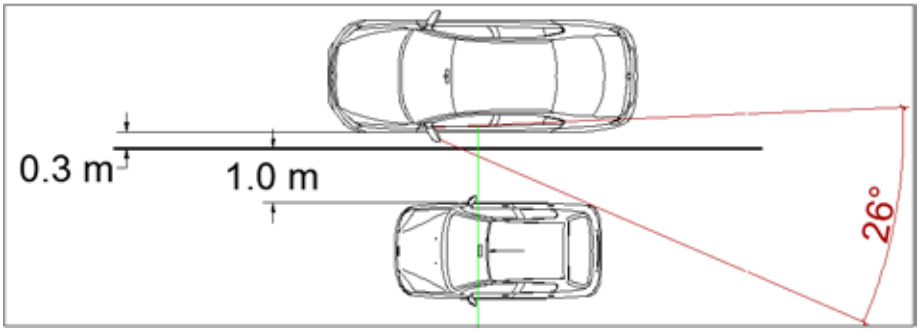

Fig. 2. Blind spot scenario

Also, for the angle visibility, it was taken into account the correct adjustment of the wing mirrors, because an incorrect adjustment can make a different in blind spot awareness. In figure 3, an example of a mirror being correctly adjusted compared to a wrong adjustment.

Fig. 3. Wing mirror's adjustment, left and right

The measurement difference between the two situations was noted and will be presented in the following part of the study research.

4 Results

The first results are the visibility angles measured on the two vehicles, they are presented in table 1. The angles determine if the vehicles on the other lane are visible when they are in the drivers' blind spot. Also, these angles were obtained by adjusting the mirrors in the correct position.

Table 1. Visibility angles

Visibility angles	*Mid-size saloon*	*Small Hatchback*
Left mirror	26°	25°
Right mirror	21°	14°
Center mirror	21°	22°

Both vehicles have almost the same angle on the driver's side, angle due to the fact that the vehicles have a blind spot area at the left edge of the mirror, and the visibility is increasing.

First scenario is for the mid-size saloon. In figure 4, the position in which the vehicle on the other lane is no longer visible in the side mirrors. The green line represents the position in which the driver can easily see the vehicle when attempting

to change lanes. In this case, the mirrors are adjusted correctly and, it is clear that the blind spots are eliminated and the small vehicle can be seen by the driver. This is because the mirrors on the saloon are capable of eliminating the blind spots if the side mirror is adjusted correctly, due to manufacturer design.

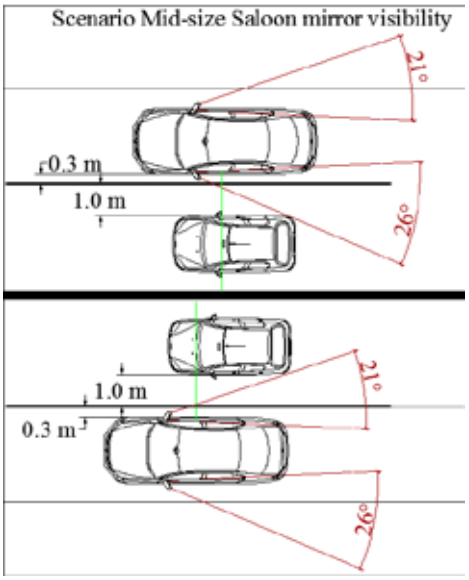

Fig. 4. Saloon blind spot scenario

In the second scenario, shown in figure 5, the similar case was presented but using a small hatchback. While the mirror on the left is acceptable, on the right the angle is low, and the vehicle on the other lane is not visible.

From the scenarios, it can be concluded that both vehicles have no problem on the driver's side, but on the right side, the visibility may be lower on some vehicles.

Another problem that was studied was the correct adjustment of the wing mirrors on the vehicles. This test was done only on the saloon because the hatchback has a poor visibility. The results are presented in figure 6.

A correct adjustment can be described as to adjust the mirrors as far as possible to cover the blind spot areas on the side of the vehicle. Unfortunately, not all drivers know this fact and adjust the mirrors in a comfortable position, as shown in the above figure. While on the left side there is little difference, on the right one, instead, there is a major difference of 5 degrees.

For the small hatchback a solution was tested, the use of small extended mirrors mounted on the edge of the wing mirrors. These will increase the angle of visibility in the blind spot area.

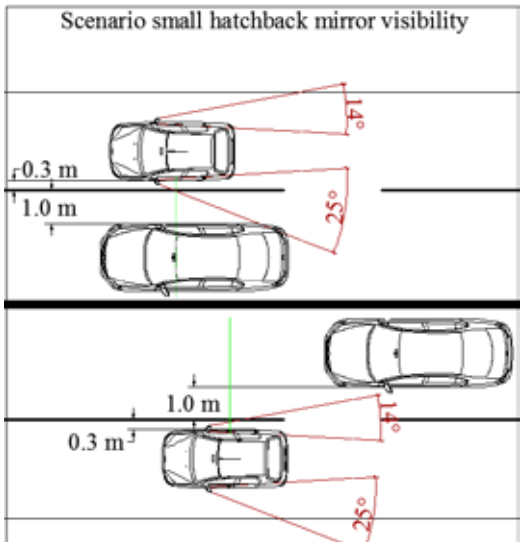

Fig. 5. Hatchback blind spot scenario

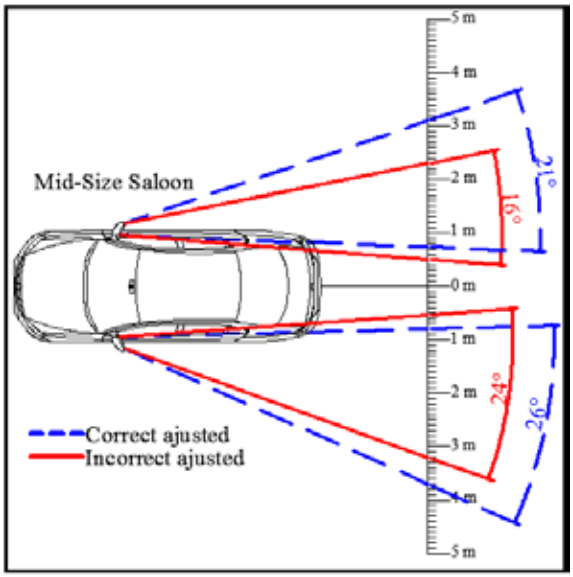

Fig. 6. Comparison between a correct adjustment and a wrong adjustment of the wing mirrors

As shown in figure 7, the use of small blind spot mirrors can increase the visibility field by 17 degrees. This is the most reliable and simple solution in eliminating blind spots.

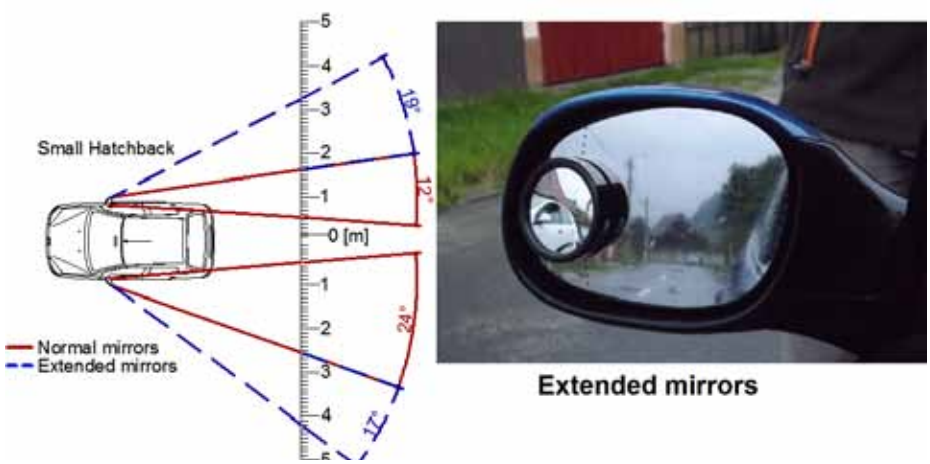

Fig. 7. Use of extended mirrors

As a solution for letting the drivers know how to correctly adjust the mirrors, a simple illustration with instructions should be included in every vehicles owner's manual. The illustration is presented in figure 8.

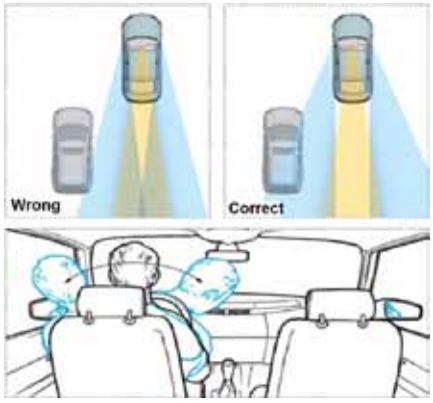

Fig. 8. Adjusting the mirrors [5]

The instructions are presented as it follows:

- Interior mirror must be adjusted to include the area behind the car.
- Side mirrors must allow viewing from the sides of the vehicle blind spots that does not include a comfort zone and the interior mirror view.

Firstly, the driver's seat position should be adjusted. The head of the driver should lean until it touches the left window and adjust the mirror until one barely sees the rear bumper. It then changes the position to the right at a similar distance (about next interior mirror) and makes adjustments for the right mirror.

Doing adjustment in this way, one can observe objects in blind spots without having to change the head position. Traffic can be seen in the rear-view mirror much easier.

A fact taken into account is the size of the wing mirrors and how it influences the visibility angles. In figure 8, a comparison is presented, between the sizes of the driver's side mirrors on both vehicles.

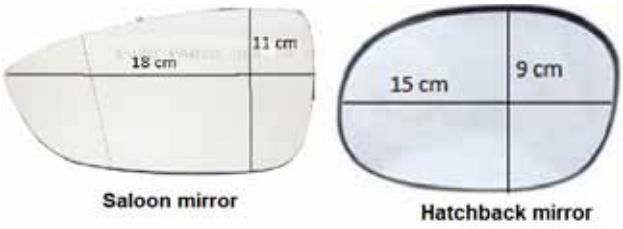

Fig. 9. Comparison of vehicles mirror size

The smaller vehicle has a smaller mirror in size and from the results presented earlier on it can be concluded that the mirror size does not influence the visibility angle, this is due to the existence of the blind spot area on edge of the mirrors. Although on the right side there is a significant difference.

5 Conclusions

Mirror visibility is vital when traveling on a multilane road, inside and outside the city, especially on highways. Blind spots can cause accidents, and this phenomenon can be eliminated easily.

The difference in visibility angles between a correctly adjusted mirror and a comfortable adjusted one can be up to 32% on the right side and 6% on the driver side. The small difference on the driver's side is due to the blind spot area located on the edge of the mirror.

As a solution, blind spot mirrors, mounted on the edge of the wing mirrors will increase blind spot visibility by 80% on the driver's side and on some vehicles, by 100% on the right side. It is worth mentioning that the right-side mirror does not have a blind spot area.

The size of the wing mirrors do have an impact on the visibility angle, resulting in having a bigger mirror, meaning a wider angle and a better view.

A suggestion can be made to eliminate blind spots is to instruct drivers to adjust their mirrors correctly. This can easily be done by including instructions of how to do this in every vehicles owner's manual.

References

1. S Christian Böffel, Jochen Müsseler, “Adjust your view! Wing-mirror settings influence di tance estimations and lane-change decisions”, Transportation Research Part F, Germany, (2015)
2. Gipps, P. G. A model for the structure of lane-change decisions. Transportation Research Part B: Methodological, 20(5), 403s–414s (1986)
3. Knapp, J. M., & Loomis, J. M. Limited field of view of head-mounted displays is not the cause of distance underestimation in virtual environments. Presence: Teleoperators and Virtual Environments, 13, 572–577 (2004).
4. Hahnel, U. J. J., & Hecht, H. The impact of rear-view mirror distance and curvature on judgements relevant to road safety. Ergonomics, 55, 23–36 (2012)
5. http://automobil-info.blogspot.ro/2009/07/reglarea-oglinzilor-retrovizoare.html *accessed on 5.06.2016*