

Development of Double-reflection Mirror System for Front-side Blind Spots

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ABSTRACT

A mirror system was developed that enables viewing of front-side blind spots. This mirror system uses a double-reflection optics system that eliminates image inversion and produces intuitive images that help prevent misconception. The effects when mounted on a vehicle were verified, and the mirror system was confirmed to enhance abilities to pull up to curbs and drive through narrow passages.

1. Introduction

Vehicles structurally have spots that cannot be directly viewed from the driver's seat, known as "blind spots." In particular, there are blind spots near vehicles, and many users feel some unease concerning these blind spots. This is especially true for users who are not used to driving, many of whom feel that they are not good at pulling up to side objects, parking, or performing other more complicated steering maneuvers. Recent advances in camera technology have enabled practical application of technologies that display images of the areas around vehicles on LCD screens such as those used in navigation systems, and have been favorably received.

This paper introduces a method that enables users to intuitively view front-side blind spots that could not adequately be viewed before, using a combination of a flat mirror and a convex mirror. Intuitive here refers to the ability to view properly aligned images without the vertical or horizontal inversion characteristic of mirrors.

2. Double-reflection Optics System Configuration

Mirrors are practically applied in various formats to view blind spots around vehicles. In particular, trucks, buses and other large vehicles have blind spots, and multiple mirrors for viewing these blind spots are attached (Fig. 1).

However, these are single mirrors, so images are always inverted vertically or horizontally, and experience is needed for accurate recognition. A combination of two

mirrors such as in a periscope (Fig. 2) can be used to obtain properly aligned images without inversion. This study used the principle of a periscope with the aim of viewing properly aligned images of front-side blind spots that could not adequately be viewed before.



Fig. 1 Example of mirrors for blind spots

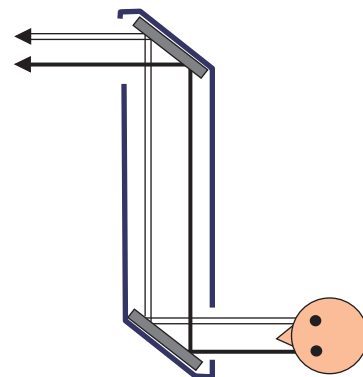


Fig. 2 Principle of periscope

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2.1. Target Blind Spots

One scene that users who are not good at driving feel uneasy about is passing oncoming vehicles on narrow passages. This is because the blind spots that extend forward from the front wheel fenders (front-side blind spots) make it necessary for each driver to judge the distance between their vehicle and the curb, gutter or other object using only their vehicle sense⁽¹⁾. In addition, due to design trends and the desire to provide an exhilarating field of view, few recent vehicles enable the driver to see the hood, making it even more difficult to sense and discern areas near the vehicle. Therefore, the target was to enhance visibility of the front-side blind spots (Fig. 3), which can be expected to increase convenience in practical situations, such as when pulling up to a curb or a toll booth, or driving through narrow passages.

2.2. Optics Design

Figure 4 shows a schematic diagram of the optics system that enables viewing of the front-side blind spots. This optics system can present a properly aligned image using the double-reflection of two mirrors installed inside and outside of the cabin.

The mirrors inside the vehicle (inner mirrors right, left) are flat mirrors, and the mirrors outside the vehicle (outer mirrors right, left) are convex mirrors. Table 1 shows the parameters of each mirror.

2.3. Image Appearance and Visible Area

Cameras installed on the door mirror housing as shown

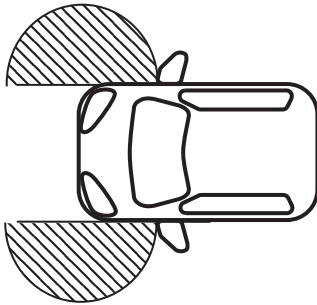


Fig. 3 Target field of view

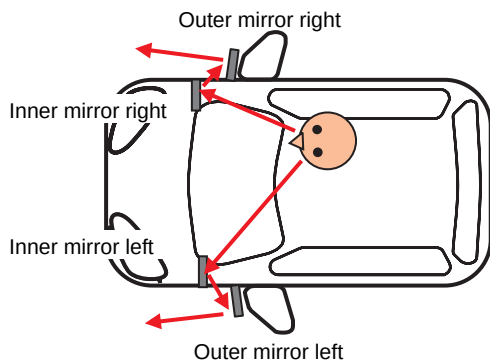


Fig. 4 Mirror layout

Table 1 Mirror parameters

Spec.	Right	Left
Eye point-inner mirror distance	924 mm	1262 mm
Inner mirror-outer mirror distance	175 mm	175 mm
Inner mirror area	1945 mm ²	3148 mm ²
Outer mirror area	5277 mm ²	6674 mm ²
Inner mirror curvature	Flat	Flat
Outer mirror curvature	R100 mm	R120 mm
Inner mirror angle	24.8 deg	48.7 deg

in Fig. 5(a) that enable viewing of the front-side blind spots have already been practically applied. The image displayed by these cameras is a properly aligned image of the area near the front wheel as viewed directly from near the door mirror as shown in Fig. 5(b), so it is easy to recognize.

The position of the flat mirror and the curvature of the curved mirror in this mirror system were investigated to provide a forward birds-eye view centering on the area near the front wheel, similar to the above noted camera images. A small mirror size is better for reducing the design and structural limitations. Therefore, this mirror system was designed to effectively utilize a small mirror area by showing a larger image of blind spots the driver wishes to see in the sideways direction, alongside the vehicle, and a smaller image that displays a wide range in the forward direction [Fig. 6(a)]. Fig. 6(b) shows an example of how the image appears generated using mirror optics simulation. As shown in Fig. 6(c), the visible area extends forward from the rear edge of the front wheel to the horizon, and to the side for approximately 1 m from the side of the body. This visible area can be changed by changing the mounting position and curvature of each mirror.

2.4. Mirror Layout

The Life (2004 year model) was selected as the base vehicle, and this system was installed.

The inner mirrors (inside flat mirrors) were installed at the base of the A pillar garnish near the front edge of the triangular window so as not to obstruct the direct field of view [Fig. 7(a)].



(a) Camera on mirror housing



(b) View of front-side

Fig. 5 Front-side view camera system

In addition, the outer mirrors (outside convex mirrors) were fit smoothly to the surface of the door mirror housing to avoid creating any new outside protrusions and realize an integrated design [Fig. 7(b)].

2.5. Exterior Design

Figure 8 shows the exterior design of a vehicle equipped with those mirror systems. As long as the vehicle has a triangular window like that of the Life used as the base vehicle, each mirror can be installed without greatly affecting the interior or body design.

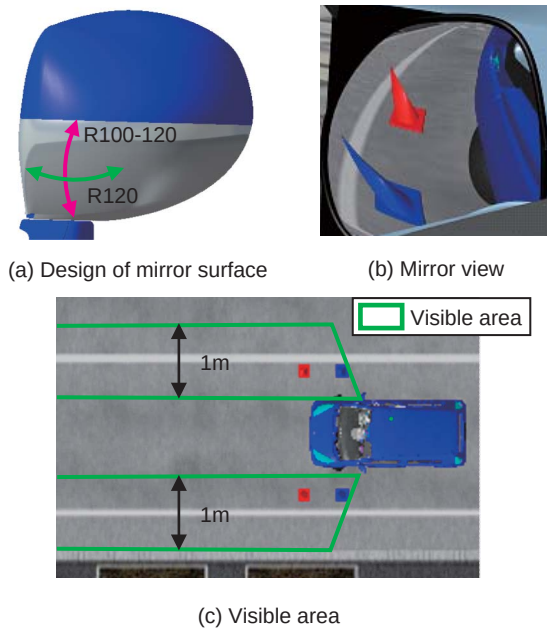


Fig. 6 Result of mirror view simulation

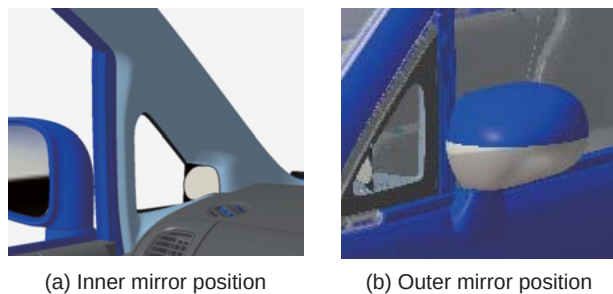


Fig. 7 Layout of each mirror



Fig. 8 Exterior view of test vehicle

3. Verification of Effects

3.1. Setting Verification Items

Pulling up to a curb and driving through narrow passages, during which a sense of where the front of the vehicle is needed, were selected as the verification items. Figure 9 shows the courses used for verification. The scene for pulling up to a curb imagined parallel parking, and care was taken to verify ease of use in conformance with reality. Driving through narrow passages imagined passing between two pylons that cannot be seen from the driver's seat in a short distance, and the ease of mind during passage was evaluated. Verification was performed after explaining the test contents to subjects solicited in-house, and obtaining their agreement.

3.2. Test Results

Figure 10 shows the change in ability to pull up to a curb for the cases with and without the mirror system. While there was no large difference in distance from the curb to the vehicle for subjects who are used to driving,

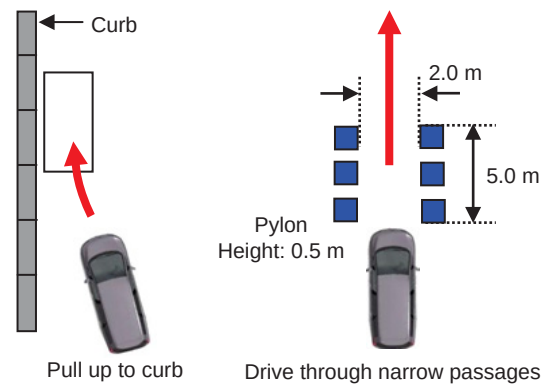


Fig. 9 Course for experiments

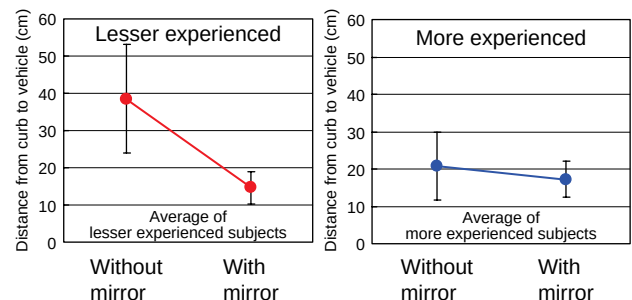


Fig. 10 Result of experiment 1

a noticeable difference was seen for subjects who were not used to driving, which confirmed that the initially targeted performance was obtained.

Next, Fig. 11 shows the sensory evaluation results for ease of mind when driving through narrow passages with and without the mirror system. Here, the responses from lesser experienced subjects in particular indicated a noticeable increase in ease of mind. Enhanced ease of mind was also confirmed for more experienced subjects due to being able to see the target objects.

Following the end of the tests, each subject's impression was obtained using a free description format. Many affirmative opinions were received, such as the following:

- It was intuitively easy to understand.
- The ability to see where one is going provides ease of mind.
- It was good to be able to understand the results of pulling up to a curb, which drivers normally perform rather casually.

In addition, issues for future enhancement were also elucidated such as the following:

- It would be better if the images were a little larger.
- Looking back and forth between the right and left mirrors is troublesome.

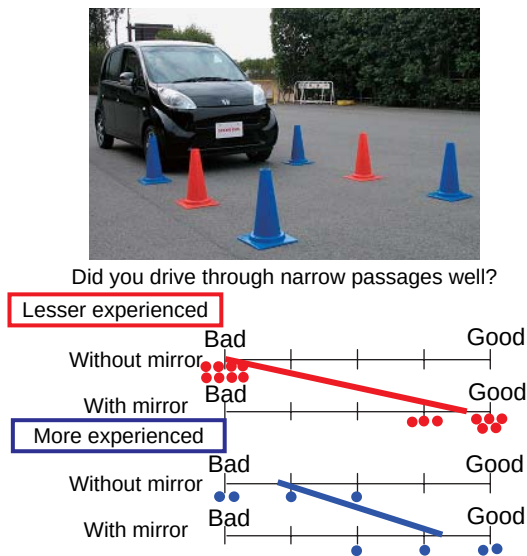


Fig. 11 Result of experiment 2

4. Conclusion

A mirror system that enables viewing of front-side blind spots was developed and mounted on a vehicle to verify the effects. The results confirmed that the mirror system enhanced abilities to pull up to curbs and drive through narrow passages. Future plans include the ergonomic investigation of mirrors to enable easier recognition, and quantization of mirror parameter requirements.

Note that the results of this study were applied as side view support mirrors⁽²⁾ to the 2010 year model STEP WGN.

References

- (1) Honda, co, Ltd. Honda web site: Anzen unten no pointo, sharyoukankaku. <http://www.honda.co.jp/safetyinfo/kyt/master/master03.html> (in Japanese)
- (2) <http://www.honda.co.jp/STEPWGN/webcatalog/equipment/>

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