NaviView: Virtual Slope Visualization of Blind Area at an Intersection

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ABSTRACT

"NaviView" represents our concept of visual assistance for drivers at the wheel. Here, we propose a new visual assistance system that can visualize the blind area behind other large vehicles under real driving conditions. Our system visualizes the blind area as a virtual slope and reduces collision accidents while turning over opposite lanes at an intersection.

KEYWORDS
AHS, NaviView, Visual assistance, Image warping, Mixed reality, Blind intersection

INTRODUCTION

Traffic accidents are critical problems for road transportation systems, and delay of recognition is one reason for their occurrence. There is a time delay for drivers to locate pedestrians and/or vehicles that emerge suddenly from blind areas. When a driver proceeds into an intersection, there may be blind areas behind vehicles waiting to make a turn in the other direction. Therefore, it is necessary to visualize these blind areas to reduce traffic accidents.

We have proposed a system for visual assistance, "NaviView" [1], which visualizes the driver's blind area using roadside surveillance cameras to reduce the delay in recognition of objects emerging from the blind area. As part of NaviView, Ichihara *et al.* proposed a system that displays a bird's eye view of the road in front of the vehicle [2], while Yano *et al.* proposed displaying the blind area as a virtual slope at an intersection [3].

These previous studies evaluated the visual effect on drivers through simulation experiments, and showed that the methods used are effective. However, it is also important to show that they are feasible under actual driving conditions. In this paper, we describe an approach to realize the virtual slope visualization method in a real vehicle environment.

VIRTUAL SLOPE

As part of NaviView, we have proposed a visual assistance method to visualize the blind area as a virtual slope to decrease collision accidents of a vehicle making a turn over opposite lanes at an intersection.

As traffic drives on the left in Japan, when turning right at an intersection, the driver may fail to see the area occluded by other vehicles waiting in the right-turn lanes coming in the opposite direction. In this case, it is difficult to see vehicles coming straight into the intersection in the opposite direction because they are hidden by the vehicles turning right.

Therefore, we propose to utilize roadside surveillance cameras to visualize blind areas. These surveillance cameras can observe the blind area because they are usually installed at elevated positions. However, when the driver sees the image from the surveillance camera ("road-view image") on a dashboard display in the vehicle, it may take some time to recognize the relative spatial relations between the driving and oncoming vehicles shown in the road-view image. There are two reasons for this delay in recognition: it is difficult for the driver to know the viewpoint of the surveillance camera at the intersection and the locations of other vehicles instantly, and the camera positions may differ among intersections. Our method eliminates these problems because a synthesized image of the blind area is always shown in the same manner at every intersection. The key concept is that part of the road-view image is superimposed into the driver's view in the shape of a slope starting from the stop line on the opposite lane (Figure 1) [3].

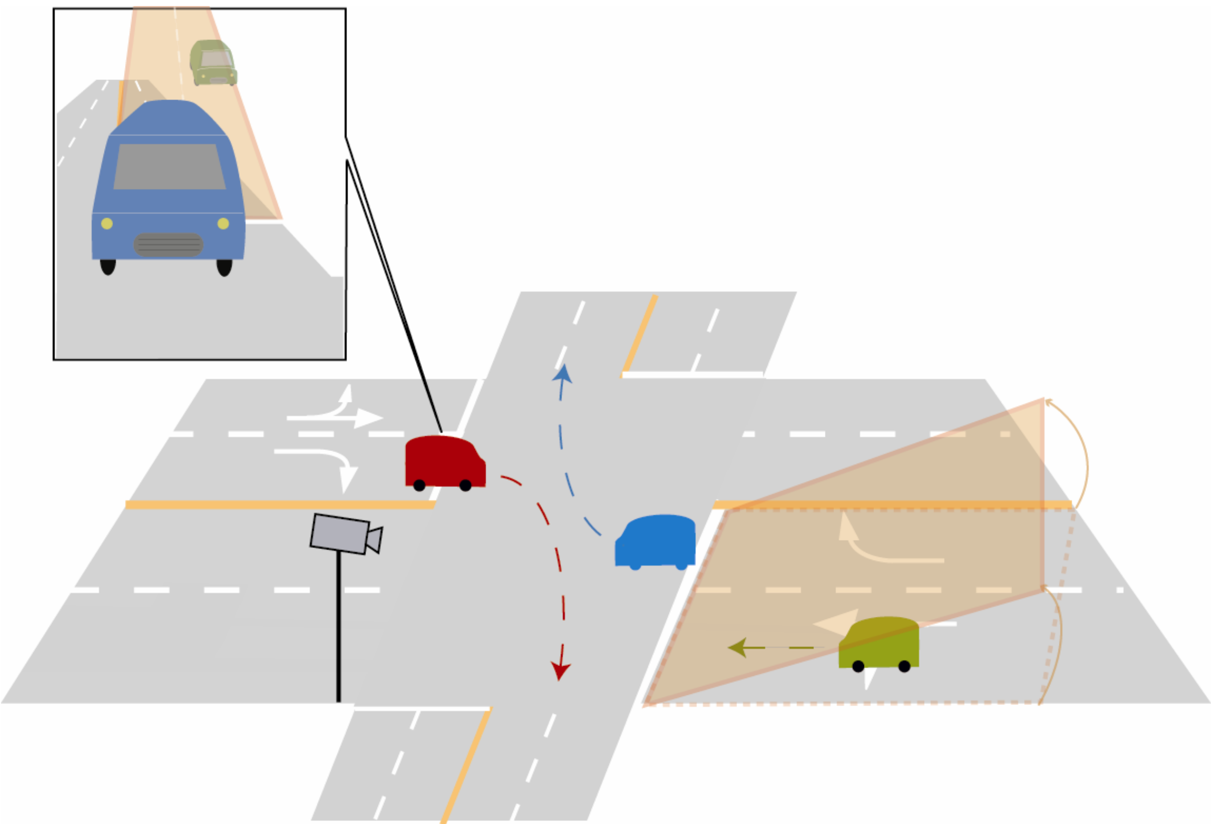

Figure 1. Outline of the virtual slope

SYSTEM OVERVIEW

We have developed a prototype system that realizes the method described above. Our system, as shown in Figure 2, is divided into two parts: a road-view transmission part and an in-vehicle image warping part. The image warping is done in the driving vehicle.

The road-view transmission part includes a surveillance camera, a server PC, and a wireless LAN facility. The server PC compresses each road-view image taken from the surveillance camera, and transmits the image to the driving vehicle through the wireless LAN.

The in-vehicle image warping part includes a driver-view camera, a dashboard display, and a client PC. The driver-view camera is set close to the eyes of the driver so that it captures an image that is similar to what the driver actually sees. The client PC receives road-view images from the server PC *via* the wireless LAN and calculates geometric warping. We call the warped image a "hidden lane texture." The hidden lane texture is imposed into the image of the driver-view camera and is shown to the driver at the dashboard display. We call the synthesized image a "virtual slope image." We assume that the vehicle position needed to make a virtual slope image will be obtained by GPS, a digital compass, and an inertia sensor.

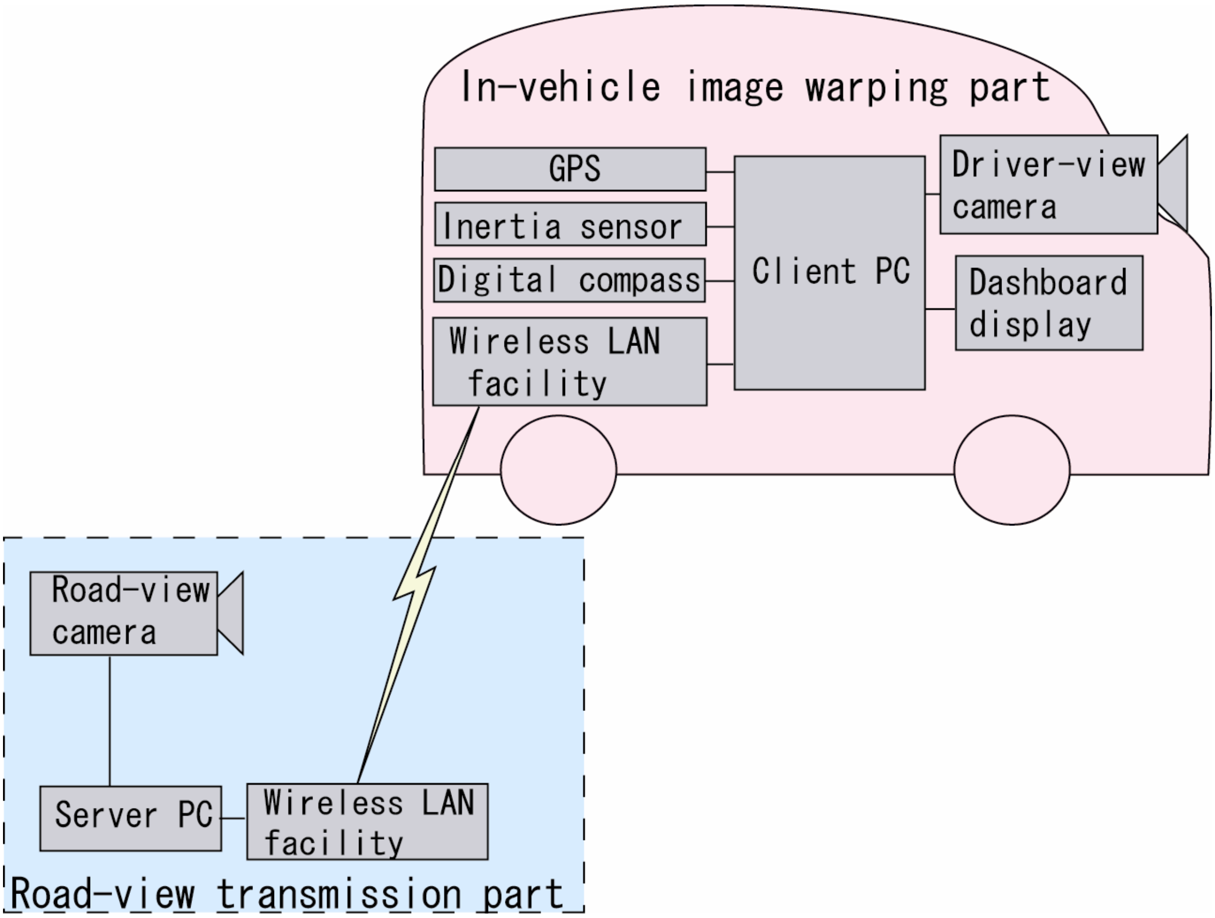

Figure 2. System structure

GENERATION OF VIRTUAL SLOPE IMAGE

In this section, we describe the generation of a virtual slope image on the client PC. A region of the hidden lane texture that will form the virtual slope can be found in a fixed location in road-view images because the relation of the world coordinate and the surveillance camera is fixed and can be given in advance.

On the other hand, the location of the driver-view camera changes as the vehicle moves. Therefore, it is necessary to obtain the camera registration parameters of the driver-view camera by which the client PC generates the virtual slope image, because the hidden lane texture must be fit to the stop line in the image of the driver-view camera. If the location of the driving vehicle is given, the relation between the driver-view camera and the world coordinate can be estimated by referring to the driving vehicle location and the parameters of the driver-view camera. Using this relation, the hidden lane texture can be imposed into the image of the driver-view camera so that the texture is fit to the stop line (Figure 3).

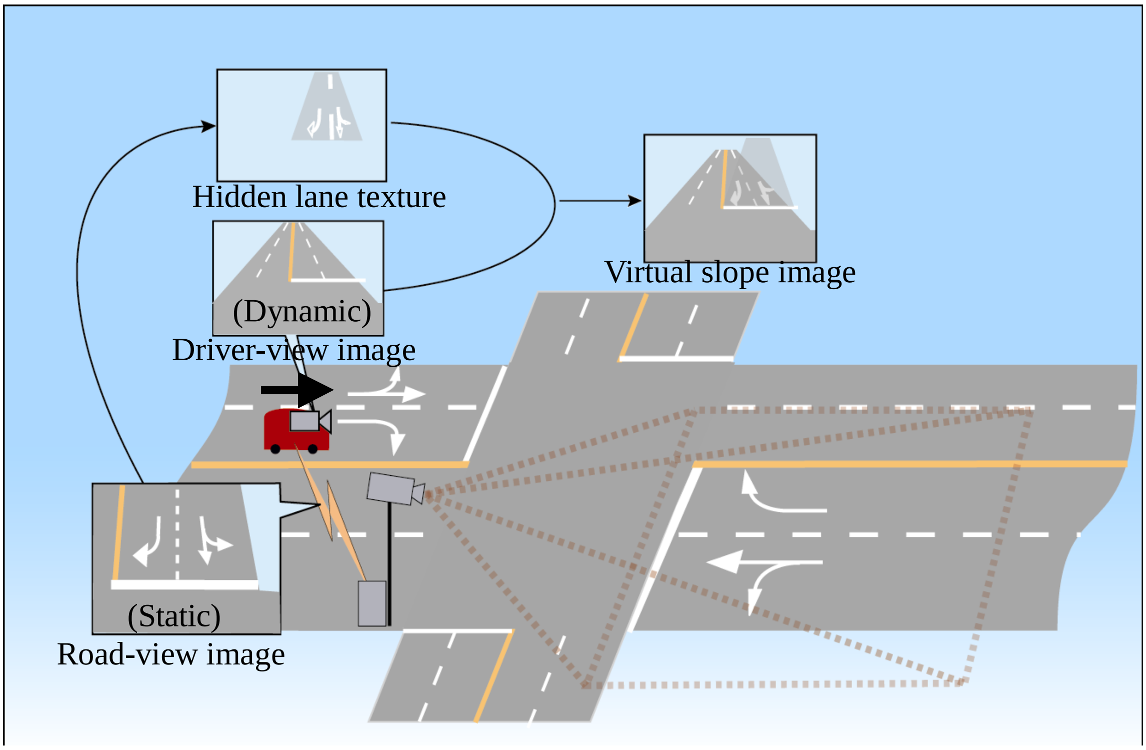

Figure 3. Process for making a virtual slope image

CORRECTION OF VEHICLE POSITION

Generation of the virtual slope image requires the position of the driving vehicle obtained by GPS, a digital compass, and an inertia sensor. However, these sensors have some errors and may cause displacement between the hidden lane texture and the stop line in the driver-view camera images. So, we corrected the vehicle position by utilizing characteristic objects (road signs) the locations of which in the intersection and their images have already been obtained. In this paper, we call these characteristic objects “landmarks.”

First, a landmark image is projected onto the driver-view camera image, and the best match location of the projected landmark image is searched in the driver-view camera images by template matching. We estimate the displacement of the matched location from the original location where the landmark is initially projected, and correct the location and orientation of the driving vehicle through repeated calculation based on the ICP algorithm [4][5] that minimizes the displacement.

EXPERIMENTS

We set up a surveillance camera at an intersection in the campus of the University of Tsukuba. The camera is mounted on a pole at a height of 5 m from the road surface (Figure 4). Our system synthesizes a virtual image from the road-view image captured by the surveillance camera and the image captured by the driver-view camera. The driver-view camera is set on the dashboard in front of the driver.

Figure 5 shows a virtual slope image that the vehicle position is obtained by the sensors. Close-up images are shown in Figure 6. The left image is the driver-view image. A vehicle behind a right-turning vehicle is proceeding toward the intersection, but the vehicle cannot be seen at the eye-point of the driver. As shown in the figure, the oncoming vehicle can be seen easily in the virtual slope. However, there may be displacements because of sensor errors.

Figure 7 shows a virtual slope image in which the vehicle position is corrected utilizing the landmarks shown in Figure 8. The virtual slope is shown in the image on the right, which is shown in the dashboard display of the driving vehicle (Figure 9). The displacements in Figures 5 and 6 are eliminated here.

Figure 4. A surveillance camera at the University of Tsukuba

Figure 5. Driver-view image (left) and virtual slope image (right)

Figure 6. Close-up images of Figure 5

Figure 7. Corrected virtual slope image

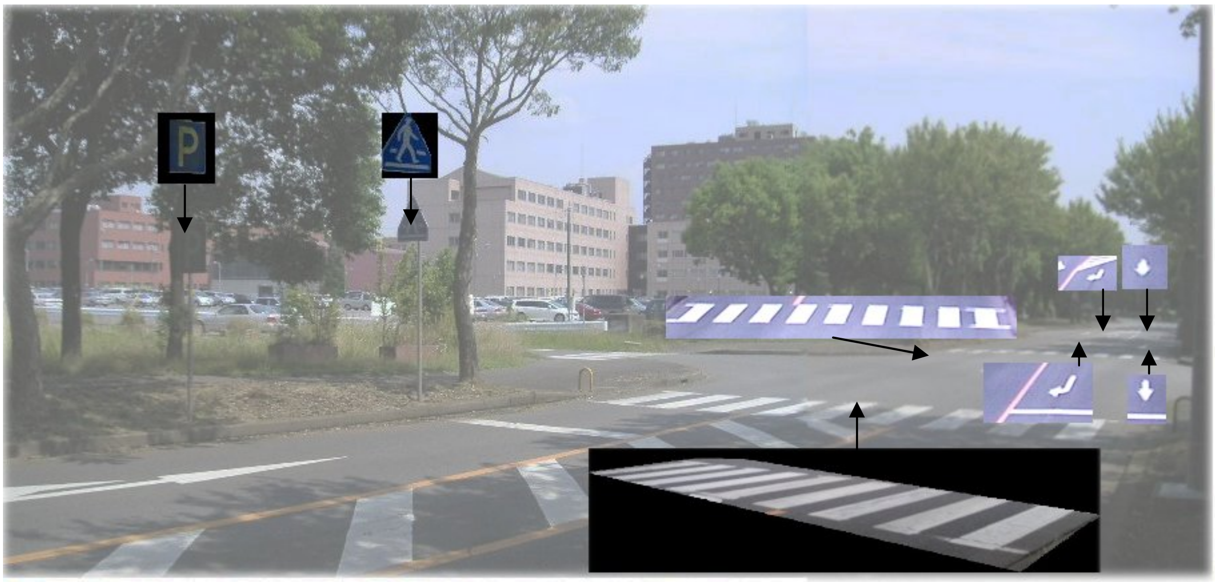

Figure 8. Landmarks used in the experiment

Figure 9. Virtual slope on a dashboard display

CONCLUSIONS

We propose a visual assistance system that displays the blind area in the shape of a virtual slope to decrease collision accidents at intersections where a vehicle is about to make a right turn.

Our current implementation requires precise camera registration parameters of the driver-view camera, which cannot be estimated by the system in real time. We are planning to integrate a real-time camera registration method. In addition, further experiments are required to evaluate the driver's perception of the virtual slope display.

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