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VISUAL ASSISTANCE FOR DRIVERS BY MIIXED REALITY

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Abstract

This paper describes our extensive research results of visual assistance for drivers based on mixed reality and discusses the technical advantages of our research framework. These include utilization of roadside cameras, development of windshield display, error-free image processing system, vision enhancement by mixed reality, and evaluation in real traffic environment. Our approaches concentrate on providing the best visual clues that can be understood intuitively and instantly for driver's vision while driving. We have already proposed novel visual assistance methods based on these research frameworks, research results of which include a virtual mirror and a virtual slope.

INTRODUCTION

Security and safety in traffic are crucial considerations in the ITS literature. We believe that the security and safety of drivers can be promoted not by utilizing fully automated systems that take over full control of the car maneuvers, but by improving drivers' ability with intelligent assistance systems. Among various driver assistance methods, vision-based assistance is useful because it can convey rich information to drivers.

We have been developing novel visual assistance methods for deployment on driving vehicles for a number of years. Two outstanding features of our approach in hardware are the utilization of windshield display (WSD) and utilization of roadside cameras.

The WSD is a key device showing rich visual information to drivers because it does not require the driver to move their line of sight markedly while watching the displayed information. In addition, with mixed reality techniques, the visual clues shown in WSD can be aligned to the real world that the driver actually sees.

External video images taken by roadside cameras are processed and fit to the driver's vision by the mixed reality technique, which is recognized as very useful in the computer-human interaction literature. The most important point in utilizing roadside camera images is to avoid any potentially faulty image processing, such as image segmentation, region extraction, and object recognition. We apply only the geometric warping process on images, because it is guaranteed to work in any situation.

Based on the equipment, we have achieved a visual assistance system. The system shows visual clues in a sophisticated way based on the mixed reality techniques. We also pay attention to the evaluation method, and hence we prepared an actual environment on our campus in which our system can use real roadside cameras and a WSD on a real car.

Visual assistance can be applied to any traffic situation, and we first applied it to drivers at intersections because of the high likelihood of accidents at intersections and we can expect that roadside cameras can be installed there for monitoring.

We have already proposed novel visual assistance methods based on these research frameworks. Some research results include a virtual slope [1], a virtual mirror [1], and a floating virtual mirror [3].

In this paper, we describe the underlying philosophy of our visual assistance approach reported elsewhere [1][2][3] and then review them from this viewpoint.

TECHNICAL FEATURES

Our research framework has five outstanding points that distinguish our studies from those of other groups. These five topics are essential to embody novel and useful vision assistance in mixed reality, and are described in this section.

UTILIZATION OF ROADSIDE CAMERAS

Sensing the traffic situation is essential for intelligent support of drivers. Many studies have introduced on-board cameras and/or radars to monitor the vehicle's surroundings. However, as on-board sensors are located at most a few meters (of the order of the size of the vehicle) away from the driver's viewpoint in the vehicle, the sensing outputs are not so different from the view of the driver geometrically. This means that some areas that the driver cannot see are invisible from the on-board sensors. For example, if there is a truck near the vehicle, neither the driver nor the on-board sensors can see the areas behind the truck. A different viewpoint is needed to observe the occluded areas in such situations.

Roadside cameras (surveillance cameras) are available for this purpose. As the cameras are likely to be installed at intersections that have higher possibility of accidents, we feel that utilization of roadside cameras is a good solution to monitor the occluded areas

of the vehicles at intersections.
Inter-car communication between vehicles with on-board cameras is another possible solution to monitoring the occluded areas. However, as this approach is available only when both vehicles have the same infrastructure, it is not good for safety and security purposes. On the other hand, the utilization of roadside cameras relies only on the road infrastructure and the equipment of the driver’s vehicle, and so the driver can always receive visual assistance at intersections.

DEVELOPMENT OF WSD

Although the WSD is a promising device as on-board display in vehicles, currently no commercial WSD solutions are available. We have implemented a prototype WSD on an actual vehicle and utilized it for evaluation purposes. This is a preliminary device but it embodies most of the functions required of a WSD.

RECOGNITION ERROR-FREE SYSTEM

Although various image processing techniques are available, some of which have been reported to show high recognition performance and robustness over scene changes, we carefully avoid any image processing because it may fail even if the error rate is very low. Therefore, we only apply the geometric warping process to images. As geometric warping never fails in any type of situation, we can guarantee that the system will always work in any traffic situation. To make visual clues in mixed reality, it has been reported that it is only necessary to apply geometric warping.

VISION ENHANCEMENT BY MIXED REALITY

Although roadside cameras can provide images of occluded areas, the video image itself is not easy to understand if the image is just shown directly to drivers. This is because the drivers do not know the location and orientation of the camera. For example, even when the camera can capture the image in which the driver’s vehicle exists, they probably could not point out their position in the image in seconds. This task (locating their own vehicle in a bird-view image) requires a high degree of mental attention of the driver, and may adversely affect safety because they will not see the scene in front of them while performing such a task.
We apply the mixed reality technique so that the image of the roadside cameras can be recognized easily and instantly. The images are geometrically warped and displayed on

a head-up display to align the warped image to the real world visually. The details of the alignment method were described previously [1][2][3].

In addition, on showing the visual clues to drivers, we introduce windshield display (a very wide HUD that utilizes most of windshield glass area). The drivers are not asked to move the line of sight when they see visual clues on the windshield because the clues are mixed with the view of the real world in the driver's vision system.

REAL ENVIRONMENT FOR EVALUATION

It is important to evaluate the visual assistance methods in real traffic scenes. We have prepared a real intersection on a road located inside our campus area. It has two lanes and is recognized as an ordinary road. Not only ordinary vehicles but also regional public buses run through the intersection on this road.

We have installed roadside cameras on top of the poles at a height of 5 m, which is the same as the height of signals on regular roads. Four poles were installed for each direction (Fig. 1), with a further one pole placed 70 m away from the intersection. The images of the cameras are captured by the PCs at the poles, and transmitted to the driver's vehicle *via* wireless LAN. We also own a vehicle (Honda "Mobilio Spike") for field tests.

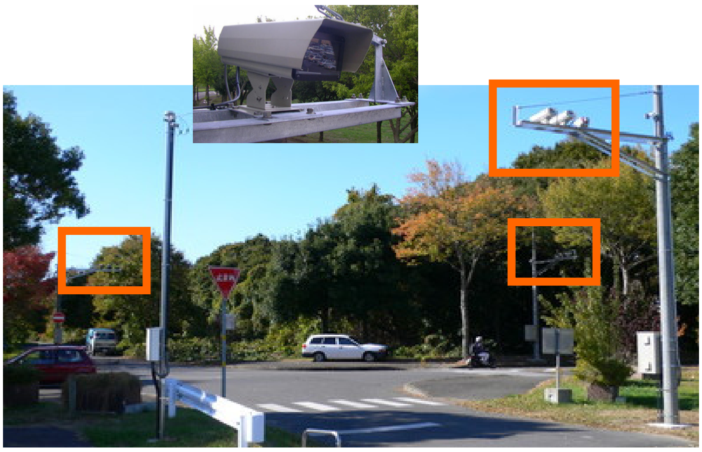

Figure 1. Experimental environment on our campus.

REALIZATION OF VISUAL ASSISTANCE

In this section, we review our proposed methods from the viewpoint of visual assistance by mixed reality. Detailed descriptions are available elsewhere [1][2][3][4][5].

WINDSHIELD DISPLAY

In our research, we assume that a windshield display (WSD) is available on vehicles. WSD has a number of advantages, including: (1) wide view, (2) high resolution, and (3) see-through vision to the real world. Although WSD is a promising device, no commercial WSD is yet available. Therefore, we have developed a prototype WSD [4]. The light from the projector is reflected at the retro-reflective screen and converges at the driver's viewpoint (Fig. 2). Therefore, the WSD is bright enough to display the visual clues on the screen even in daytime.

WSD can reduce the eye movement on watching the visual clues on the screen rather than watching the monitor screen on the instrument panel. However, it is possible that the displayed visual clues may interfere with the driver's view. We have analyzed and discussed the placement strategy of visual clues in WSD [5].

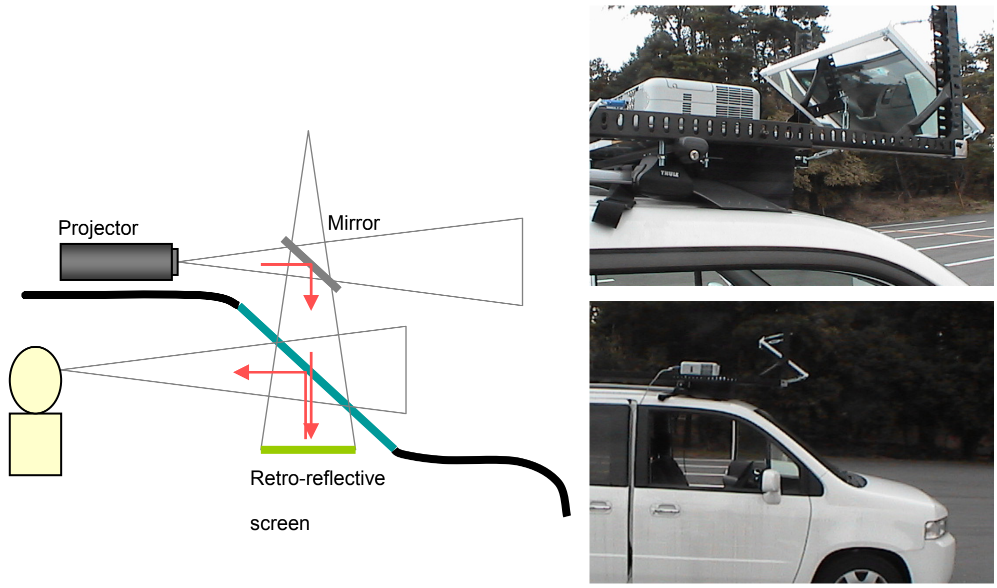

Figure 2. Windshield display (WSD).

VIRTUAL SLOPE

Virtual Slope [1] is a visual assistance application that prevents traffic accidents on making turns at intersections. At a traffic situation like that shown in Fig. 3, a driver who is going to make a left turn in the red car cannot see the approaching vehicle (green car) because it is occluded by the vehicle waiting to make a left turn (blue car). However, the roadside camera installed to monitor the road can capture the approaching vehicle because it is set at a high point. The virtual slope then visualizes the approaching vehicle in the form of a slope. The virtual slope image is made by warping the roadside camera image so as to fit the virtual slope into the real intersection (top right in Fig. 3) and it is shown to the driver on the WSD in the red car.

VIRTUAL MIRROR

The Virtual Mirror [2] was developed to support a driver approaching an intersection where it is not possible to see the side roads because of buildings. The video images of the roadside cameras installed at the intersecting road are mapped in the mirror area of the virtual mirror structure by mixed reality technique (Fig. 4). As roadside cameras are usually installed in different ways, the choice of image warping method was examined previously [2]. Timing and location to display the virtual mirror are also discussed in [2]. As the virtual mirror has been evaluated only in the simulation environment, we plan to implement it in a real traffic environment in the near future.

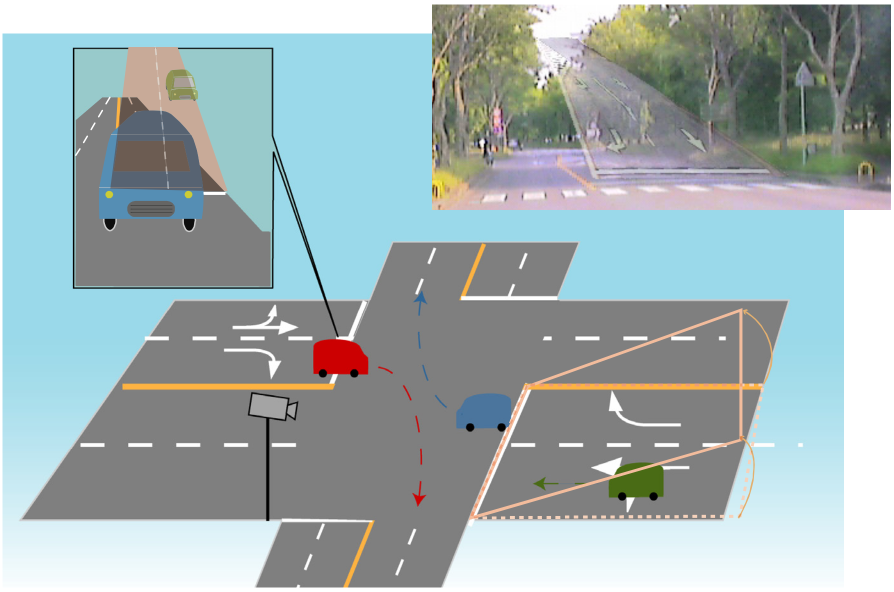

Figure 3. Virtual slope.

FLOATING VIRTUAL MIRROR

The floating virtual mirror [3] was designed to monitor the areas surrounding the driver's vehicle near intersections. Using the floating virtual mirror, the driver can see motorcycles and bicycles approaching the driver from the rear. The source image of the floating virtual mirror is taken from a roadside camera facing the driver's vehicle, and the floating virtual mirror is virtually placed at precisely half the distance to the camera from the driver's position. Therefore, it looks as though the image is moving at half speed in the same direction as the driver's vehicle, and it seems to be floating because the camera is usually located at a high point on a signal pole. Figure 5 shows a diagram of the floating virtual mirror. As the floating virtual mirror is placed in the driver's view on driving and it strictly follows the intrinsic features of real optical mirrors, drivers can instantly understand what they see in the virtual mirror even when they first see it.

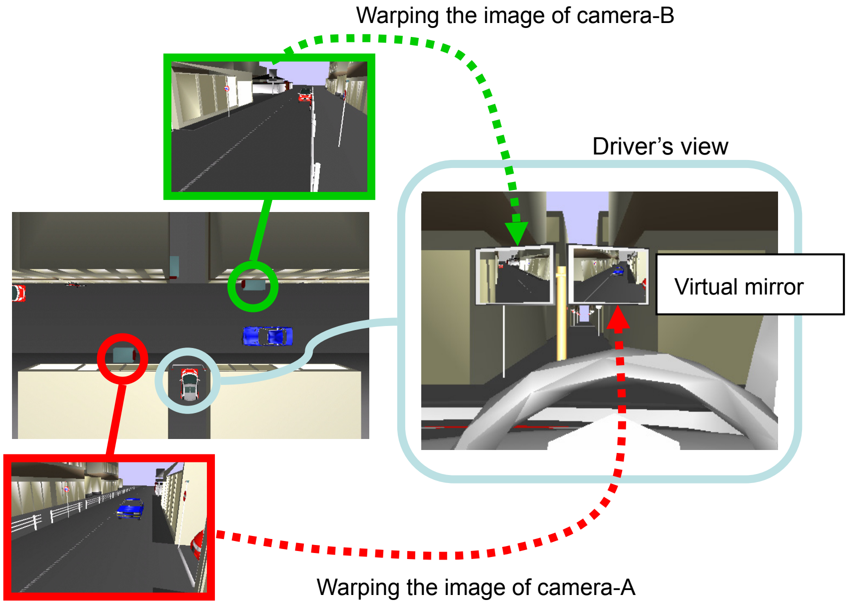

Figure 4. Virtual mirror.

CONCLUSIONS

In this paper, we described five significant features that distinguish our research from that of other groups. We utilize roadside cameras as powerful tools to eliminate blind areas that cannot be seen by drivers. The images are processed in an error-free way and the warped images are displayed so as to fit them into the real world in the driver's vision. We prepared a real traffic environment so that we can conduct reliable evaluation experiments of the proposed methods.

We feel that visual assistance should be used to achieve safety and security, but at the same time, we also feel that the visual assistance methods we have developed are fun for drivers while they drive.

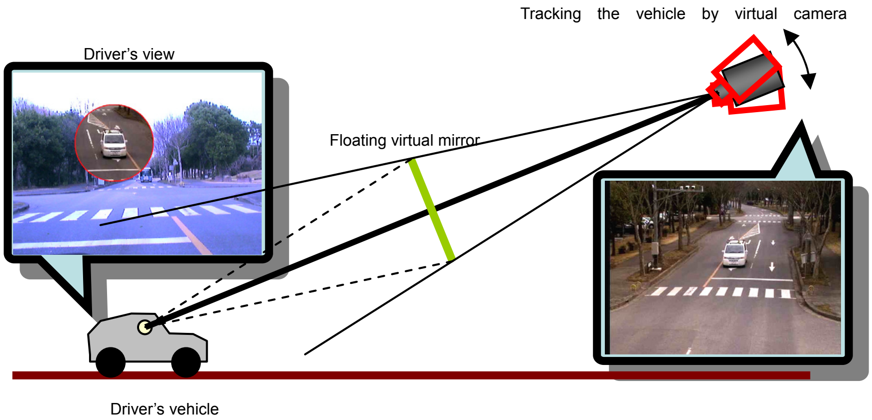

Figure 5. Floating virtual mirror.

ACKNOWLEDGMENT

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