Image Overlay on Optical See-through Displays for Vehicle Navigation

Tomoyasu Nakatsuru, Yasuyoshi Yokokohji, Daisuke Eto, and Tsuneo Yoshikawa
Department of Mechanical Engineering, Graduate School of Engineering
Kyoto University, Kyoto 606-8501, Japan
{yokokoji|yoshi}@mech.kyoto-u.ac.jp , nakatsur@mechatoro.mbox.media.kyoto-u.ac.jp

Abstract

In this paper, we propose a method for image overlay on the front glass of a vehicle to navigate a driver to a desired destination. By overlaying the navigation imformation on the front glass, the driver need not gaze at the console panel. Therefore, accidents caused by gazing at console panel could be reduced. To overlay the image accurately on the target object through the front glass, both the vehicle's position/orientation and the driver's position/orientation are estimated by vision-based tracking and measuring angular velocities of the vehicle's wheels. Experimental results show the validity of the proposed method.

1. Introduction

Recently, the diffusion rate of car navigation systems is remarkably increasing because the systems are becoming more sophisticated with lower price than before. However, accidents on the road are suddenly increasing because drivers gaze at the console panel of the car navigation system while driving a car. Therefore, it is necessary to establish a method to show information in understandable and safety manners.

Fukano et al. proposed the concept of "On-the-Scene HUD (Head Up Display)", which is a head-up display of car navigation systems by using augmented reality [1]. However, the technical method to realize the On-the-Scene HUD in real-time has not been discussed definitely.

In this paper, we propose a method to overlay virtual images for navigation on the windshield of a vehicle in real time, assuming that the windshield of the vehicle is a kind of optical see-through displays as shown in Figure 1(b). Our proposed HUD is different from conventional optical see through HMD (Figure 1(a)) in a sense that the user's head is apart from the display and it may move with respect to the display.

To validate the effectiveness of the proposed method, we made a small wagon where two cameras were attached for tracking the markers in the environment and on the user's face, respectively. It was shown that the proposed method could give helpful information to navigate the vehicle.

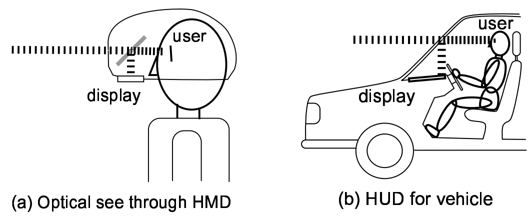


Figure 1. Optical see through HMD and HUD for vehicle

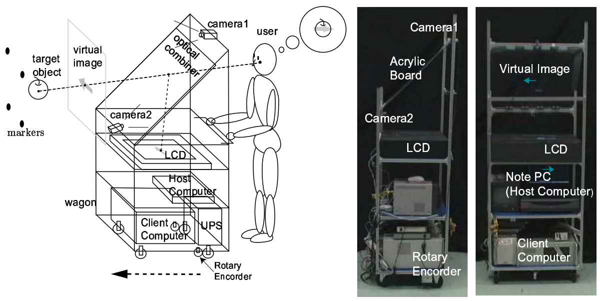
2 System configuration

We must calculate not only vehicle's position and orientation but also user's position and orientation with respect to the vehicle in order to overlay the virtual image accurately on the real scene of the environment through the windshield.

Figure 2(a) shows an overview of the system that was developed to validate the effectiveness of the proposed method shown in this paper. As shown in Figure 2(a), the vehicle is a wagon, which can be guided manually by human. The vehicle's position and orientation are estimated by tracking the environment markers with camera 1 (shown in Figure 2(a)) and by measuring angular velocities of the vehicle's wheels with rotary encoders attached to the wheels.

The user's position and orientation are also estimated by tracking markers on the user's face, located at user's both eyes, nose and mouth, by camera 2 (shown in Figure 2(a)).

These positions and orientations can be estimated by using Kalman filter [2], and a navigational information is displayed on the LCD according to the estimated positions and orientations. An acrylic board is used for optical combiner, corresponding to the vehicle's windshield. An user can see the navigational information projected from the LCD. Following the displayed navigation information, the user can



(a) System configuration (b) Overview of the vehicle

Figure 2. System configuration and experimental apparatus

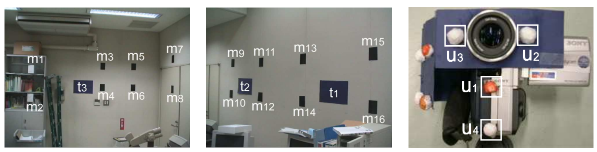


Figure 3. Locations of environment markers, user's markers and target objects

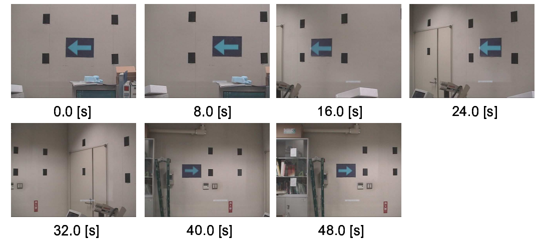


Figure 4. Sequence of navigation images (Experiment 1)

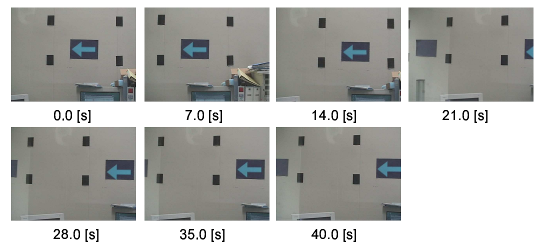


Figure 5. Sequence of navigation images (Experiment 2)

move the wagon to a designated location. Figure 2(b) shows an overview of the developed experimental vehicle.

3. Arrangement of markers and targets

Figure 3 shows an overview of our laboratory where several targets $\mathrm{t}_1 \sim \mathrm{t}_3$ and markers $\mathrm{m}_1 \sim \mathrm{m}_{16}$ are attached on the walls and the shelf. As shown in Figure 3, we attached four markers $\mathrm{u}_1 \sim \mathrm{u}_4$ on a digital video camcorder, corresponding to the user's eyes, nose and mouth. We assume that what the video camera captures is what the user can actually see.

4. Navigation experiment

We conducted navigation experiments by using the developed system. To check the tracking performance for the environment markers and the user's marker separately, we moved either the vehicle (Experiment 1) or the user (Experiment 2).

In Experiment 1, we estimated the vehicle position. Fixing the user's position, the vehicle was moved from the initial position to the goal position, following the displayed navigation guide as shown in Figure 4.

In Experiment 2, we estimated the user's movement. Keeping the vehicle stationary at the initial position, the user (actually the video camera) was moved assuming a head shaking motion. Figure 5 shows the sequence of the captured image by the video camera. In Figure 5, one can see that the virtual arrow image was not overlaid on the left target at t= 21.0[s] because this target was out of the acrylic board from the user's viewpoint at that time. From Figures 4 and 5, we can see that the navigation information was accurately overlaid on the target objects even when the vehicle or the user is moving.

5. Conclusion

In this paper, we proposed a method to overlay navigational information on the right position in the real scene thorough the windshield of the vehicle by augmented reality technique. As the future works, we should perform indoor navigation experiments in various places and we must study a method to track natural markers robustly. After that, we should implement our system in a real vehicle and try some outdoor navigation experiments.

References

[1] J.Fukano, S.Okabayashi, and M.Sakata. Automotive Head-Up Displays for Navigation Use. *The 14th International Technical Conference on Enhanced Safety of Vehicles*, (94-S2-O-02):306-314, 1994.

[2] Y. Yokokohji, Y. Sugawara, and T. Yoshikawa. Accurate Image Overlay on Video See-Through HMDs Using Vision and Accelerometers. *Proceedings of IEEE VR 2000*, 247-254, 2000.