[POSTER] Overlaying Navigation Signs on a Road Surface using a Head-Up Display

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ABSTRACT

In this paper, we propose a method for overlaying navigation signs on a road surface and displaying them on a head-up display (HUD). Accurate overlaying is realized by measuring 3D data of the surface in real time using a depth camera. In addition, the effect of head movement is reduced by performing face tracking with a camera that is placed in front of the HUD, and by performing correction of projection images according to the driver’s viewpoint position. Using an experimental system, we conducted an experiment to display a navigation sign and confirmed that the sign is overlaid on a surface. We also confirmed that the sign looks to be fixed on the surface in real space.

Index Terms:  H.5.1 [Information Interfaces and Presentation]: Multimedia Information Systems—Artificial, augmented, and virtual realities

1 INTRODUCTION

To realize comfortable and safe driving, visual support to drivers is important. In particular, car navigation systems which provide visual and audio route guidance are widely used. However, most of them display maps and navigation signs on a small monitor, which prevent drivers’ intuitive understanding of information, and it is also a problem that drivers have to gaze at the screen.

To solve these problems, systems using a head-up display (HUD), which projects images on a transparent screen such as a windshield, have been developed. Drivers can see both displayed information and a real scene at a time while keeping their eyes ahead. However, displayed images often look distorted or misaligned when the driver’s viewpoint moves. There has been research on distortion correction considering a driver’s viewpoint position [2], but overlaying objects on a real scene has not been performed. There has been research on navigation systems that overlay route information on a road surface using real scene information [1], but image projection on a transparent screen and image correction according to a driver’s viewpoint position have not been performed.

In this paper, we propose a method for overlaying navigation signs on a road surface using real-time 3D sensing information and displaying them on a HUD according to a driver’s viewpoint position. Overlaying navigation data on a real scene helps drivers’ intuitive understanding of information and natural route guidance is realized.

2 SYSTEM CONFIGURATION

The experimental system we built consists of a prototype HUD developed by Calsonic Kansei Corporation, two cameras (a camera for calibration and a camera for face tracking), a depth camera (Microsoft Kinect for Windows), and a PC (Intel Core i5-4670 3.40GHz CPU, 8GB memory).

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3 FLOW OF PROCESSING

In this section, the flow of processing for overlaying navigation signs on a road surface and displaying them on the HUD is described. First, 3D data of a road surface is measured using the depth camera and the plane on which navigation signs are overlaid is estimated. Then, a driver’s viewpoint position is detected by face tracking and a projection image to the viewpoint is generated. Lastly, the projection image is inversely distorted using the calibration data and is projected on the HUD.

In the 3D measurement of a road surface, a depth image is obtained from the depth camera and is converted to 3D point cloud data.

In the plane estimation, assuming that the overlay region on a road is flat and can be approximated by a plane, the equation of the plane is calculated by the least squares method using some sample points in fixed locations.

In the viewpoint detection, the face tracking camera captures an image of the driver and 3D coordinates of the viewpoint are obtained from the position of the driver’s dominant eye and the distance between the eyes in the image.

In generating a projection image, objects to be overlaid are rotated and translated so as to be on the estimated road plane. Since the measured 3D data is in the coordinate system of the depth camera, it is transformed to the coordinate system of the viewpoint. The positional relationship between the depth camera and the viewpoint is shown in Fig. 2.

After coordinate transformation, perspective projection with the center of projection at the driver’s viewpoint is applied to generate a projection image. Figure 3 shows the perspective projection with viewpoint movement. The eye direction is set so as to gaze at the fixed position of the virtual image plane, which is consistent with that in the calibration.
The generated image is projected on the screen glass of the HUD. Since the screen glass is tilted, the projected image becomes distorted. This distortion can be reduced by performing calibration of the HUD and inversely distorting the projection image using the calibration data.

In the calibration, gray code pattern images, in which the coordinates of the pixels in a projection image are encoded, are projected on the HUD and the calibration camera captures the images of the displayed patterns. Then, the transformation map from camera image coordinates to projection image coordinates is generated. The map is resized to the size of the image to be displayed (input image) and is smoothed to generate the transformation map from input image coordinates to projection image coordinates.

This is repeated several times with different viewpoint (calibration camera) positions. Using the results, linear regression equation for coordinate transformation on a viewpoint position is obtained in each input image coordinates. In this study, we assume that the viewpoint movement in the z-axis direction is small and the 2D coordinates of the dominant eye in the camera image is used as a viewpoint position. The coefficients of the regression equations are smoothed in the image space, and are stored in a look-up table (LUT). In each viewpoint, the calibration camera is placed so as to gaze at the center of the virtual image plane. When projecting images on the HUD, coordinate transformation is performed in each image coordinates using the coefficients of the regression equation in the LUT and the viewpoint position obtained by the face tracking camera.

4 EXPERIMENT

We conducted an experiment to confirm that a navigation sign that is overlaid on a road surface actually looks overlaid on the road surface from a driver. Figure 4 shows the images seen from a driver with changing viewpoints. The images seen from center, top, bottom, left, and right positions are shown. Figure 5 shows the images seen from a driver with changing orientations of the road surface. The surface is tilted in the vertical and horizontal directions.

The navigation sign was projected according to the driver’s viewpoint and it looks like being fixed on the road surface in real space. Realtime 3D measurement of the road surface enabled overlaying the navigation sign on the road surface even if the orientation of the road surface was changed.

The processing speed was about 8 fps and there was a small amount of delay in displaying the navigation sign. This is mainly due to plane estimation and distortion correction. The speed would be increased by improving the algorithms or by using a dedicated hardware.

5 CONCLUSION

In this study, we proposed a method for overlaying navigation signs on a road surface using real-time 3D sensing information and displaying them on a HUD according to a driver’s viewpoint position. 3D data of the road surface was measured in real time using a depth camera and the navigation sign that was overlaid on the road surface was successfully projected on the HUD according to the driver’s viewpoint.

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REFERENCES
