Tablet system for visual overlay of rectangular virtual object onto real environment

Hiroyuki Yoshida*

Ricoh IT Solutions Co., Ltd.

Takuya Okamoto [†]

Ricoh IT Solutions Co., Ltd.

Hideo Saito [‡]

Keio University

ABSTRACT

We propose a novel system for visual overlay of rectangular virtual object onto real environment observed by tablet PC with camera. This system allows us to visually simulate the layout of virtual rectangular objects such as advertising posters in the field. For estimating the pose and position of the tablet PC in the 3D structure of the target environment, we proposed the procedure using the motion sensor in tablet PC. In this paper, we introduce two demonstrations about the deformation for a rectangular virtual object and the reflection of light such as sunlight.

Keywords: rectangular object, cylinder, cuboid, sunlight, spherical image

1 INTRODUCTION

We have studied the method of simulation for visual overlay of rectangular virtual object onto a given plane by using a tablet PC with camera and sensors. In ISMAR 2014, we introduced a tablet system that users arrange a virtual object on the specified plane. For estimating the pose and position of the tablet PC in the 3D structure of the target environment, we proposed the procedures using the captured image and using the motion sensor in tablet PC [1]. In this paper, we propose a novel system for the arrangement of rectangular virtual object onto plane or cylindrical surface. Lighting effects must be applied to improve reality of visual overlay. Our system enables users to simulate the reflection of sunlight on a virtual object such as outdoor advertising on site.

2 DEFORMATION OF RECTANGULAR OBJECT

We introduce a method for deformation of a virtual rectangular object by easy operation in order to arrange it onto a surface other than plane. We consider the layouts of rectangular object onto lateral surface of cylinder and cuboid in the still image.

2.1 Layout onto Side of Cylinder

First, rectangular poster is displayed at the center of the image captured by camera. The pose of this poster is adjusted to the pose of tablet PC relative to vertical position. The pose is measured by motion sensors (acceleration sensor, gyro sensor etc.). Assuming that a cylindrical object stands vertically, the pose of the object corresponds to that of the virtual poster (Fig.1-a). After taking a still image, a virtual object is relocated to the center of a cylinder object and bended to be a half cylinder once by user operations. And then its curvature is changed by pinch-in or pinch-out operation to match the curvatures of a virtual poster and a cylinder object in background image (Fig.1-b). In pinch-in or pinch-out operation, a virtual white cylinder renders on the same position to

* e-mail: hiroyuki.yoshida@jrits.ricoh.co.jp

† e-mail: takuya.okamoto@jrits.ricoh.co.jp

‡ e-mail: saito@hvrl.ics.keio.ac.jp

virtual object. This effect makes users easier to adjust the curvature (Fig.1-c). After the arrangement of a virtual poster onto cylinder, the virtual poster can be translated and rotated around the cylinder. In the case of rotation, it revolves about the central axis of the cylinder, and hides in the rear of the cylinder.

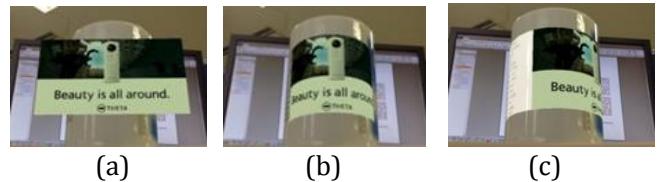(a)   (b)   (c)

Figure 1: Layout of poster onto cylinder

2.2 Layout onto Side of Cuboid

In a similar way, we can bend a rectangular poster and arrange it onto the lateral surface of a cuboid. First, a virtual poster is arranged on any plane of cuboid and relocated to the corner of cuboid (Fig.2-a). Secondly, the center of the virtual poster is bended at right angle once. And then the size of cuboid is configured by pinch-in or pinch-out operation. A virtual white cuboid renders on the same position to the virtual poster. The shift of touch position on right side corresponds to the width of a right plane, and the same goes for left side (Fig.2-b). After the arrangement of a virtual poster onto cuboid, the virtual poster can be translated and rotated around the cuboid. The shape of the virtual poster is changed according to layout position (Fig.2-c).
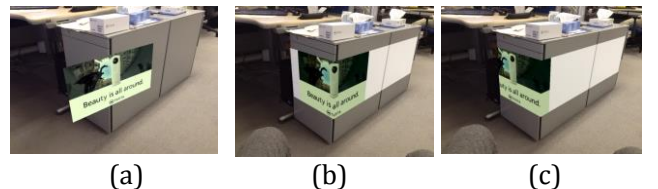

(a)   (b)   (c)

Figure 2: Layout of poster onto cuboid

3 REFLECTION OF LIGHT

We introduce two methods for simulation of the reflection of light. Lighting effects are very important for the preview of posters. First, to simulate the lighting effects of sunlight, we propose the procedure using the relative position of sun on site and the pose of a tablet PC in order to calculate the incidence angle of sunlight. Next, to simulate the lighting effects of light sources on site, we propose the procedure using spherical images captured in target environment.

3.1 Sunlight

We propose a method for the reflection of sunlight on a rectangular object by computing the position of sun [2]. For this method, we apply "cube mapping" with one square texture of artificial sun. The normal vector to a surface is rotated instead of translating the position of sun. The position of sun is derived from longitude, latitude, time and date in the field, and presented as azimuth (AZ_{sun}) and elevation (EL_{sun}). The relative azimuth of sun to a tablet PC is derived from the roll angle of tablet PC (AZ_{device})

which is obtained using electronic compass. The relative elevation of sun to a tablet PC is derived from the pitch angle of tablet PC (EL_{device}) which is obtained using gravity sensor. The rotation of a normal vector needs to be divided into halves because the variation of reflection vector is two times that of normal vector. For this reason, the rotation angles of a normal vector are presented as follows

$$\Delta R_x = \frac{EL_{sun} - EL_{device}}{2} \qquad (1)$$

$$\Delta R_y = \frac{AZ_{sun} - AZ_{device}}{2} \qquad (2)$$

where, ΔR_x and ΔR_y are rotation angles associated with elevation and azimuth respectively. Transformation matrix for normal vector (R_{normal}) is presented as follows

$$\boldsymbol{R_{normal} = R_{sun} R_{object}} \qquad (3)$$

where, R_{sun} is rotation matrix for sun position that is derived from ΔR_x and ΔR_y, R_{object} is rotation matrix for virtual object. The reflection of sunlight on vertical surface is shown as Fig. 3

Figure 3: Reflection of sunlight

3.2 Spherical Image

We propose a method for generating light source images from a spherical image. The spherical image is obtained by consumer omnidirectional camera [3]. It provides information, such as azimuth angle, horizontal angle and elevation angle, for top/bottom correction. Reflection vector of the line-of-sight in real space can be calculated from the attitude of tablet PC because virtual object is arranged on vertical/horizontal surface. Image area along the reflection vector is clipped from a spherical image and applied as light source. RGBA color values with high brightness in this image are superimposed on color values of virtual object to effect the reflection of light. We can simulate the reflection of light from multiple light sources with only one spherical image (Fig. 4).
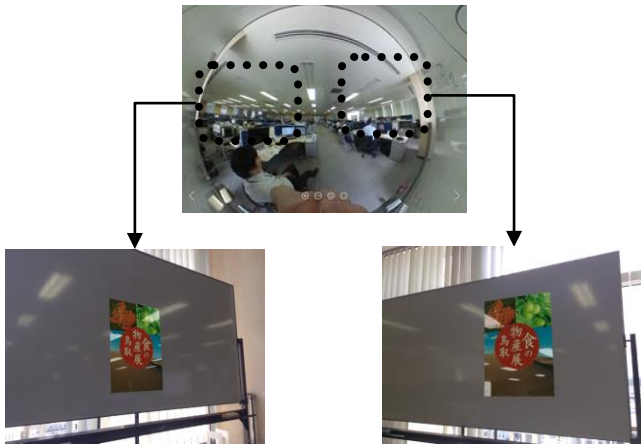

Figure 4: Reflection of light using spherical Image

4 CONCLUSION

We propose and implement a tablet system that can simulate the layout of virtual rectangular objects such as advertising posters easily. This system allows us to arrange a virtual object onto cylinder or cuboid with simple user operations. Additionally, the reflection of light on virtual object on site can be simulated by computing the position of sun or clipping light source image from spherical images.

REFERENCES

[1] H. Yoshida, T. Okamoto and H. Saito. Tablet system for visual overlay of 3D virtual object onto real environment. In IEEE International Symposium on Mixed and Augmented Reality (ISMAR), 2014.

[2] http://www1.kaiho.mlit.go.jp/KOHO/syoshi/pr_eph.htm

[3] https://theta360.com/en/