Self Bird's Eye View with Omnidirectional Camera on HMD

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Figure 1: (left) System configuration, (center) Subjective view, (right) Bird's eye view.

Abstract

The experience to see oneself from behind in real-time, that is like out-of-body experience, is refreshing, it is also expected as a trigger to improve oneself. However selfie-stick, drone, or something is necessary to take a bird's-eye view. We propose the method to make virtual self bird's-eye view using an omnidirectional camera on an HMD.

Keywords: Bird's eye view, omnidirectional camera, HMD.

Index Terms: Human-centered computing—Human computer interaction (HCI)—Interaction paradigms—Virtual reality

1 Introduction

Head Mounted Display (HMD) has become increasingly popular in recent years. Many systems display a first-person view through an HMD, instead of third-person view which is like bird's eye view. The experience to see oneself from behind in real time is refreshing, it is also expected as a trigger to improve oneself. There are researches about survey view in the sport psychology field [1]. However a selfie stick, a drone, or something is necessary to take the bird's eye view. In this paper, we propose the method to make virtual bird's eye views of oneself by using an omnidirectional camera on an HMD (Fig. 1 (left)). Objects **a** and **b** are projected to **a'** and **b'** on a dome screen respectively (Fig. 2). Here, the distance to talk with a friend can be assumed as, for example, about one meter. There are of course other objects that are not one meter from the subject, but these, especially distant objects are not payed attention. Our method is based on the assumption that objects are on a subjective dome screen (Fig. 3), and it means the distance is equal to the radius of the dome. Then we make a bird's eye omnidirectional image (Fig. 1 (right)) from the subjective omnidirectional camera image on an HMD (Fig. 1 (center)). The subject's back image is simply drawn using Computer Graphics.

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2 Mapping to Bird's-eye Dome

An object position is point *P*, that polar coordinate is (r, θ, ϕ), on a subjective coordinate *O* (Fig. 4). This *P* is projected to *P'* on a bird's eye coordinate *O'*. The radius of bird's eye dome is the same as a subjective one, and vector *OO'* is defined as (q_x, q_y, q_z). The projected point *P'* is shown as:

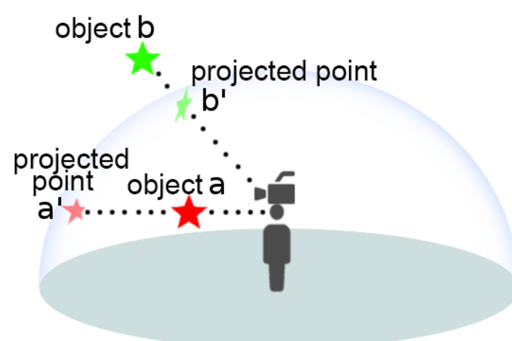

Figure 2: Dome screen and objects.

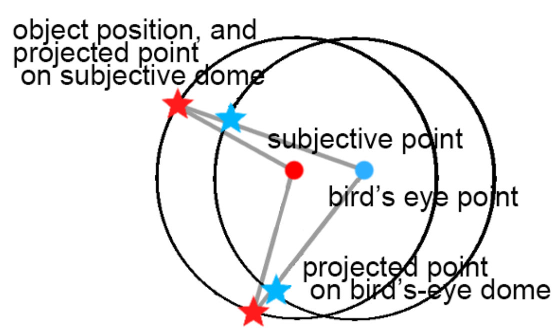

Figure 3: Two Dome screens and objects in 2D.

$$
\boldsymbol{P'} = \left(r,\ \tan^{-1}\left(\frac{r\sin\theta\cos\phi - q_x}{r\cos\theta - q_z}\cdot\frac{1}{\cos(\tan^{-1}\frac{r\sin\theta\sin\phi - q_y}{r\sin\theta\cos\phi - q_x})}\right),\ \tan^{-1}\left(\frac{r\sin\theta\sin\phi - q_y}{r\sin\theta\cos\phi - q_x}\right)\right)
$$

Fig. 5 shows a mapping example from a subjective dome to a bird's eye one. The upper illustrations are subjective dome observed from the outside below, point a, b, and c are on a front hemisphere. The vertical and horizontal lines are longitude and latitude lines drawn at regular intervals. The lower illustrations are bird's eye dome, the line just beside of the subjective dome is drawn ahead on the bird's eye dome.

3 Experiment

We used Oculus Rift as an HMD and Richo Theta as an omnidirectional camera to develop our self bird's eye view experience system (Fig. 6). The position and direction were obtained only through one sensor of an HMD. When the direction was changed from the initial position (Fig. 7 (left)), system judged that the subject changed it keeping the relation between the head and the body (Fig. 7 (center)). Three types of parameters were tested; dome radius (assumed object distance) and the offsets to the bird's eye view point are; (1) 1m, (-0.5m, 0m, 0.5m), (2) 3m, (-0.5m, 0m, 0.5m), (3) 3m, (-1.5m, 0m, 1.5m). Fifteen subjects rated each trial on a scale of 1 to 3 points, the average scores were (1) 31, (2) 15, and (3) 34 respectively. This result suggests the ratio between a radius and view point offset is more important than the absolute values. We also obtained a positive impression, especially through the type (3) and (1).

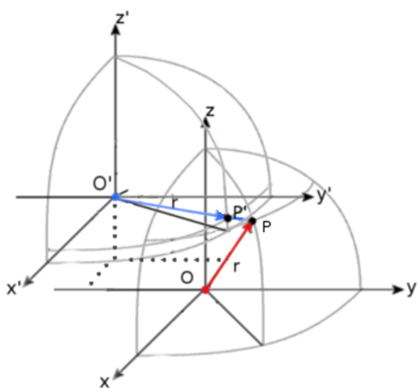

Figure 4: Two Dome screens and objects in 3D.

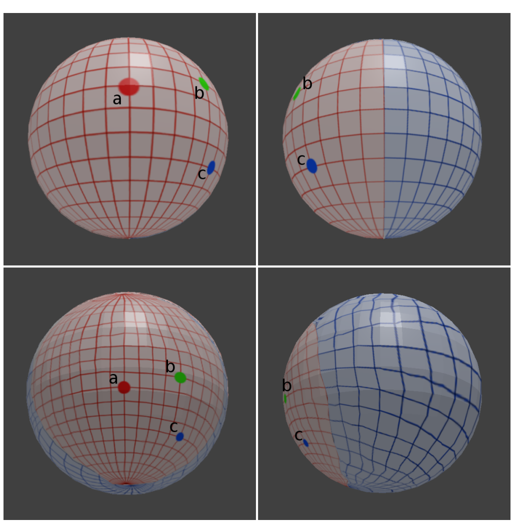

Figure 5: Dome mapping example.

Figure 6: System overview.

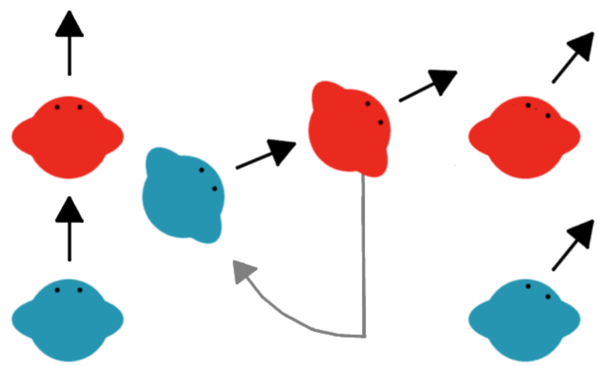

Figure 7: Top view of Head and body motions.

4 Conclusion

In this paper, we have proposed a virtual self bird's eye view experience system with binocular parallax that is relatively appropriate. It needs only an omnidirectional camera on an HMD without a selfie stick. Although you can see yourself from behind as bird's eye view, the image is slightly distorted because the UV map is made manually by using the 3D Computer Graphics tool, Blender. In the future, the UV map should be calculated appropriately. The head motion and body one also should be separated by using two motion sensors (Fig. 7 (right)). It is desirable to reflect the actual subject's back image.

References

[1] N. Fujii, H. Nakamoto, S. Ikudome, S. Unenaka, and S. Mori, "The Relationship Between Survey View and Mental Rotation in Football Players", *Japanese Society of Sport Psychology*, Vol.41, No.2, pp.93-103, 2014. https://doi.org/10.4146/jjspopsy.2014-1313