An Estimation Method for Blurring Effect in Augmented Reality

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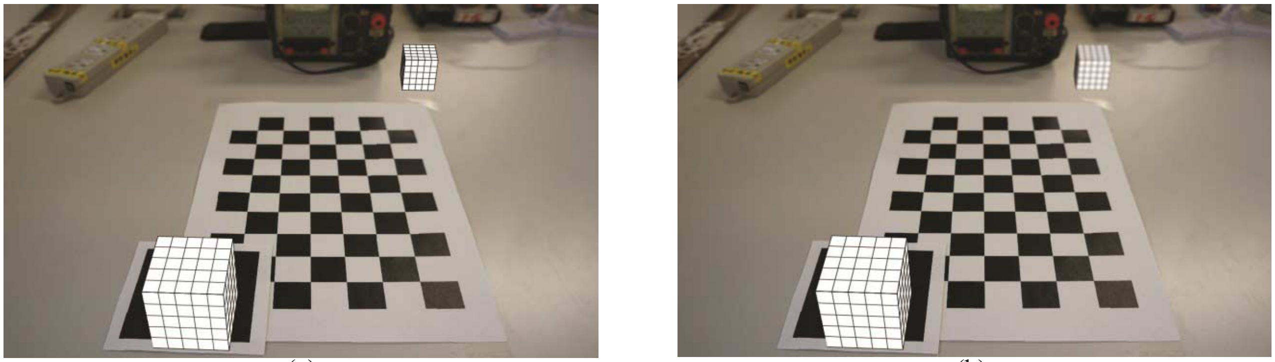

(a) (b)

Figure 1: (a) *Virtual cubes rendered with no blurring effect,* (b) *Virtual cubes rendered with the blurring effect estimated by our method.*

1 Introduction

The perceptual issues in Augmented Reality (AR) systems, is drawing more and more attention these days. Among the perceptual issues, the incorrect depth interpretations degrade user experience significantly. One way to improve the depth interpretations in AR systems is to improve the consistency of the real scene and the virtual objects by using the depth cue method based on blurring effect. In the research of [Okumura 2006], a blur rendering method based on measuring the defocusing on the AR marker from the captured real scene has been proposed. However, the blur effect could only be rendered on the marker position where the blur in the real scene is measured. This limits the practicality of the system since in many applications the virtual objects are out of the marker's range or even moving. In our work, a new method to estimate the degree of blur is proposed. This method makes it possible to calculate the degree of blur that varies spatially with the scene.

2 Our Approach

Based on the thin lens model, we found that as long as the focus length (*f*), the diameter (*D*) of the lens, the PSF (point spread function) of one point in the image and its position in the real scene, the PSF of another point on a known position could be estimated. In order to conduct this estimation, we introduce a one-time checkerboard registration method. The checkerboard is first detected and the parameters of the camera, such as position and tilting angle, are registered. The blur parameter (the blur circle radius of a point in the image, written as r in Function (1)) is calculated by measuring the intensity of pixels perpendicular to the black-white edge on the checkerboard. As shown in Function (1), when u_1 , r_1 and u_2 are known, r_2 can be calculated. In this way, the blur parameters in the whole image view can be estimated by just offering the spatial information. After the estimation process, we render the estimated blur parameter to the virtual objects in the AR system by applying Gaussian filter. A prototype of the proposed AR system was implemented in our work.

$$r_2 = R_2/\sigma = \left[\frac{u_1(u_2-f)}{u_2(u_1-f)} \cdot (2r_1\sigma + D) - D\right] / \, 2\sigma \qquad (1)$$

where u is the distance between a point in the real scene and the lens, v the distance between the lens and the image plane. σ is an introduced parameter which could be calculated by the CCD sensor size divided by the image resolution.

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SIGGRAPH 2013, July 21 – 25, 2013, Anaheim, California.

ACM 978-1-4503-2261-4/13/07

3 Evaluation and Future Work

To evaluate our estimation method, we compared the value of the measured blur parameters with the value of the estimated blur parameters (estimation value is based on part of the measurement data) on the checkerboard and found that the value of the estimated blur parameters are larger than the value of the measured blur parameters. With the increasing distance to the focus plane, the difference of the value increases. The imperfection of the imaging system is the most plausible reason to explain this difference.

In order to know how the users would perceive the different blur parameters as a depth cue, we invited 17 student observers to check the difference between the same virtual textures rendered under the measured blur parameters and the estimated blur parameters. The results showed that with the increasing distance to the focus plane, the observers are more likely to feel that the textures rendered with the estimated blur parameters show a better consistency with the background, and some even reported that they could tell which one seems farther in depth. The observers also found that the brightness of the virtual texture (the brightness of the virtual texture changes after filtering) affects their perception to some extent.

In the future work, the rendering method will be modified by making up the loss of the brightness caused by filtering. The motion blurring and the blur effect caused by lighting or other environmental factors will also be studied. This research was supported in part by a Grant-in-Aid for Scientific Research (C) numbered 25330227 by the Japan Society for the Promotion of Science (JSPS).

References

OKUMURA, B., KANBARA, M., AND YOKOYA, N. 2006. *Augmented Reality Based On Estimation of Defocusing And Motion Blurring from Captured Images. In Proc. of the 5th IEEE and ACM International Symposium on Mixed and Augmented Reality (ISMAR'06)*, 219-225.