Correction of Projector Distortion For Spatial Mixed Reality System

Hasup Lee
Konkuk University
Republic of Korea
hasups@gmail.com

HyungSeok Kim
Konkuk University
Republic of Korea
hyuskim@konkuk.ac.kr

Jee-In Kim
Konkuk University
Republic of Korea
jnkm@konkuk.ac.kr

ABSTRACT

The correction of projector distortion is a crucial problem in spatial mixed reality systems. There have been two types of correction methods; screen modeling based method [1] and calibration pattern based method [2]. The screen modeling based method is improved in this paper. The screen model is generated using range sensor and can be control the level-of-detail. As a result, the screen of complex form can be modelled and the rendering result can be viewed from moving user's position.

CCS CONCEPTS

• Human-centered computing → Human computer interaction (HCI) → Interaction paradigms → Virtual reality

KEYWORDS

Virtual Reality, Mixed Reality, Projection

1 INTRODUCTION

Recently, the development of virtual reality related industries is growing very rapidly. Although research on virtual reality has been going on since the 1960s, technology has been accumulated and remains at the research level due to high cost and hardware constraints. However, the breakthrough of virtual reality hardware in recent years has enabled us to design a virtual reality world at a lower price. Also, the participation of many companies is making the virtual reality contents rich.

Currently, most virtual reality systems can be divided into headset-based systems and dedicated spatial systems. A virtual reality headset-based system is a system in which a user uses a headset with a built-in screen and experiences a virtual reality world. Most major companies such as Microsoft, Sony, Google, Samsung, and Facebook participate in the virtual reality headset market. Therefore, it is thought that the research on the headset based system is progressing enough to activate the market.

A spatial virtual reality system is a system that requires dedicated space for the virtual reality world. A CAVE system that is implemented in a cubic space consisting of several screens is a typical dedicated spatial system. This system gives a high sense of immersion, but it takes a lot of space, and installation cost is high, so much research is needed to be popularized.

A compromise between a conventional headset-based virtual reality system and a dedicated spatial virtual reality system makes the virtual reality world partially visible in the space of everyday life. It is assumed that the user her/himself and its system space or device move together in the virtual reality world. For example, a virtual reality cockpit system and a virtual reality telescope are these compromised systems. The cockpit system will show the virtual world by replacing the window part with the screen in the actual cockpit. A virtual reality telescope will show a virtual world in the visible through the lens. The difference between a virtual reality headset and a telescope is that the headset must be hidden from the user, but the telescope is also part of the system where the user manipulates it. This system is called a spatial mixed reality system in this paper.

If we use the dedicated space in our system like CAVE, the screen can be fixed straightly. But in a spatial mixed reality system, the used screens are not straight but distorted. They are even in the form of the dorm. So, the projector distortion is the problem for the spatial mixed reality systems. There have been several researches for the projector distortion.

2 RELATED WORKS

There have been two types of correction methods of projector distortion. One is screen modeling based method [1] and the other is calibration pattern based method [2]. The details of these methods are as follows.

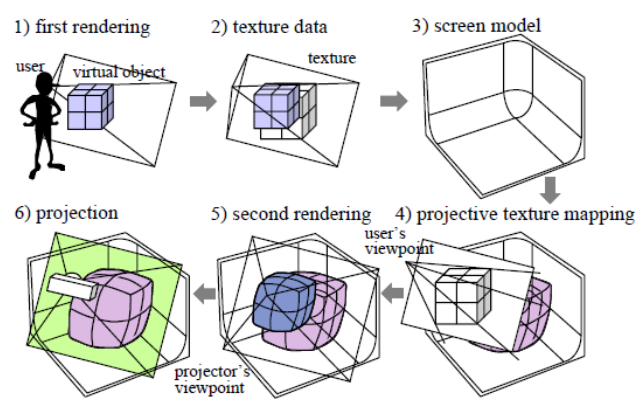

Figure 1: The procedure of the screen modeling based correction method. This figure is from [1].

2.1 Screen Modeling Based Method [1]

In the screen modeling based method, the screen is modelled manually. The texture on the screen model in virtual world made from user's viewpoint is projected to real screen. Real time correction with user's viewpoint changing is possible but the texture is needed to be recalculate every frame. And this method can be applied only when the exact screen can be modelled manually. The procedure of this method is showed in Figure 1.

2.2 Calibration Pattern Based Method [2]

In the calibration pattern based method, the calibration pattern is projected on the non-planar screen and the image warping matrix is calculated using this projected image. Complex shaped screen can be projected using this. This method is useful only when user's viewpoint is fixed of move slightly like cockpit or dome environment. The procedure of the calibration pattern based method is as follows.

1) Projecting calibration pattern (check board pattern)
2) Taking a photo of the pattern from user's viewpoint
3) Image warping - calculate matrix ***R***: photo → pattern
4) Applying ***R*** after transformation in rendering
5) Projection

3 SCREEN MODELING WITH RANGE SENSOR

Figure 2: Screen modeling with range sensor and projection into that screen model. (Mesh model is concept image.)

We are improving the screen modeling based method [1] in modeling phase. The screen is modelled with a range scanner like Figure 2, so the screen based method [1] can applied the screen cannot be modelled correctly by hand. A mesh are made from the scanned results (range images) using the marching cubes algorithm [3] because the jittered data and merging problems can be handled using this algorithm [4]. Then the raw mesh is simplified using octree based simplification method [4]. This simplification can be directly applied the results of the marching cubes algorithms. Because the level-of-detail model of screen is generated after modeling phase, we can use the screen model of proper details proportional to rendering load.

The procedure of our screen modeling is as following steps. After making screen model, we can replace fixed model to our model at step 3) of Figure 1. Additionally, the level-of-detail of screen model is determined at this step based on system load or user parameters.

Table 1: The procedure of screen modeling with range sensor

	Steps	methods	results
1)	Scanning the screen	range camera	range images
2)	Merging the range images into mesh	marching cubes algorithm [3]	raw mesh
3)	Make level-of-detail model	octree based simplification [4]	level-of-detail screen model

4 DISCUSSION

In this extended abstract, we improve the screen modeling based correction method of projector distortion but our method is now under implementing. Then, the result and analysis of it will be presented soon.

Tracking user's eye position is another crucial problem in the spatial mixed reality system. We aim to develop the system without any annoying devices attached to users. Under restricted environment like a cockpit, very sensitive sensor like 'leap motion' [5] can be used for this.

5 CONCLUSIONS

In our approach, the screen of complex form can be modelled and the rendering result can be viewed from moving user's position. Screen modeling based correction method of projector distortion is improved by screen modeling with a range scanner. This approach can be applied spatial mixed reality systems.

ACKNOWLEDGMENTS

This work was supported in part by the Next-Generation Information Computing Development Program through the National Research Foundation of Korea funded by the Ministry of Science, ICT, and Future Planning under Grant 2012M3C4A7032185, and in part by the Bio-Synergy Research Project under Grant 2013M3A9C4078140 of the Ministry of Science, ICT, and Future Planning through the National Research Foundation.

REFERENCES

[1] Tetsuro Ogi, Masahiro Hayashi, Mitsutaka Sakai: Room-sized Immersive Projection Display for Tele-immersion Environment, 17th International Conference on Artificial Reality and Telexistence (ICAT 2007), pp.79-86, Esbjerg, Denmark, 2007.11.28-30.

[2] Tetsuro Ogi, Yoshisuke Tateyama, Hasup Lee, Daisuke Furuyama, Takeharu Seno, Takuro Kayahara: Creation of Three Dimensional Dome Contents Using Layered Images, The 1st International Symposium on Virtual Reality Innovations (IEEE ISVRI 2011), pp.253-258, Singapore, 2011.3.19-20.

[3] W.E. Lorensen & H.E. Cline, Marching Cubes: A High Resolution 3D Surface Construction Algorithm, Computer Graphics, 21 (4), 1987, 163–170.

[4] Hasup Lee and Hyun S. Yang, "Marching-Cube-and-Octree-Based Level-of-Detail Modelling of 3D Objects", International Journal of Modelling and Simulation (ISSN: 0228-6203), Vol.29, No.2, pp.121-126, February 2009.

[5] Weichert, Frank, et al. "Analysis of the accuracy and robustness of the leap motion controller." Sensors 13.5 (2013): 6380-6393.