A TILED DISPLAY SYSTEM FOR IMMERSIVE EDUCATION

Sang-Youn Kim
Interaction Lab. Korea University of Technology and Education
307 Gajeonri, Byeongcheon-myeon, Cheonan, Chungnam, 330-708, Korea

Hyen-Keun Park, Do-Yoon Kim
Withrobot Lab. 4F Dueon Bldg, 1708-6, Seocho-Dong, Seocho-Gu, Seoul, 137-070, Korea

Keywords: Virtual Education, Virtual Reality, Virtual Training, CAVE, Tiled Display.

Abstract: Virtual reality systems may be used as a new educational tool because a user can be provided immersive sensation as he/she experiences a real object. A tiled display is one of the virtual reality systems which generates high-quality images and guarantees wide view angle using multiple projectors. In this work, we present a tiled display system which has high resolution screen (its resolution is 4096 x 1536 and its effective resolution is 3200x1200). We apply a seamless technique to this system in order to remove joint lines and to improve the quality of images. Furthermore, we implement educational contents for experiencing a CMOS manufacturing process based on the proposed tiled display system.

1 INTRODUCTION

Even though many education systems provide a wide range of benefits for students, the education systems have some problems to be solved before accepting. One of these problems is that many systems do not provide immersion and the sense of reality to users. Virtual reality technology allows users to experience the same sensation as if they watch and feel real objects. Therefore, the education system based on the virtual reality technology can be a solution for immersive training because VR systems enable users to experience phenomena in virtual environment which are difficult to illustrate in real world. Furthermore, users can learn how to operate a machine or a target device in virtual world.

Virtual reality technology in its early stage has been focused on displaying and rendering the shape of a target object on 2D monitors or limited screens. These systems are not suitable for the following cases: 1) where visual contents are important; 2) where high resolution display is necessary; and 3) where a wide field of view is required. For these cases, researchers have developed tiled display systems (Hereld et al., 1999; Yang et al., 2001; Chen et al., 2001; Krishnaprasad et al., 2004) which can generate high resolution images and can fill up users' field of view with the images.

This paper proposes a tiled display system where a high resolution image generates by binding images obtained from multiple low resolution projectors. Furthermore, we implement the educational contents on the proposed tile display system.

2 SCREEN

One of the most important factors in virtual reality is to convey the sense of reality to users. The sense of the reality means that a user feels or experiences an object in virtual world as the object exists in real world. The one of the conditions to increase the sense of the reality is to fill a user's field of view (FOV) with high resolution virtual images. Humans have an almost 180^o forward-facing field of view (FOV) and 120^o an effective FOV (Authur, 2000).

There are four major screens for expressing virtual environment: (1) a wall type, (2) a cylindrical type, (3) a dome type, and (4) a CAVE type. Since the advantage of a tiled display system is to share a virtual environment among users, we decided to choose a cylindrical type screen which provides a wide FOV. However, when virtual images are

Kim S., Park H. and Kim D. (2009).
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In *Proceedings of the First International Conference on Computer Supported Education*, pages 394-397

projected on the cylindrical screen, it is necessary consider a complex calibration method for generating continuous images. Another problem is that the position of a target object is hard to compute and to present on the cylindrical type screen.

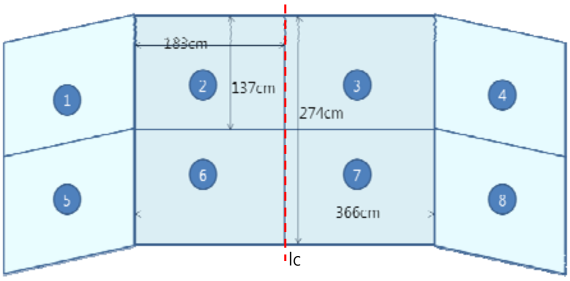

Figure 1: The shape and the size of the proposed screen.

Therefore, in this work, we implemented a folded type screen which brings into relief the advantage and supplements the disadvantage of the cylindrical screen as shown in Figure 1. Since each sub-screen in the folded type is flat, the proposed tiled display system is not only easy to establish, to maintain, and to repair but also easy to calibrate. In Figure 1, each part (①~⑧) is a projection area. In this symmetric screen, the angle of refraction between the left sub-screen (①, ⑤) and the middle sub-screen (④, ⑧) is 120°. If the distance between a user and the screen is 1 meter, the field of view becomes about 160°.

3 SYSTEM ARCHITECTURE

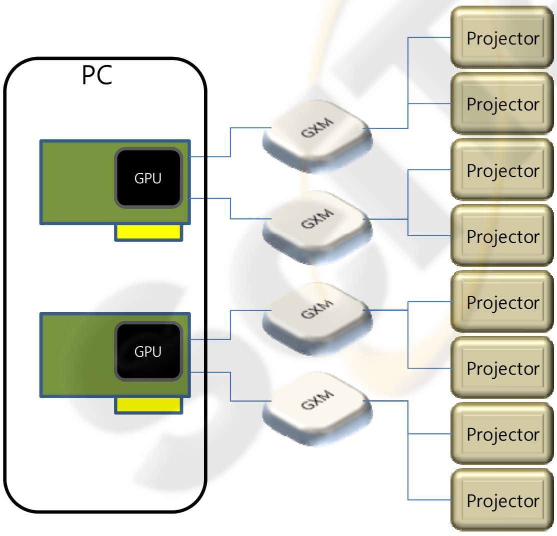

Figure 2: Hardware system architecture.

Figure 2 shows the hardware configuration of the proposed system. The system was implemented with a single PC and 2000 ANSI DLP projectors whose resolution is 1024 x 768. Two graphic cards were included in the single PC and each graphic card has two graphic output ports. Each graphic output port has a Graphics eXpansion Modules(GXM) which can connect two visual displays. Therefore, our system generates high resolution image by connecting eight projection areas with a single PC as shown in Figures 2 and 3.

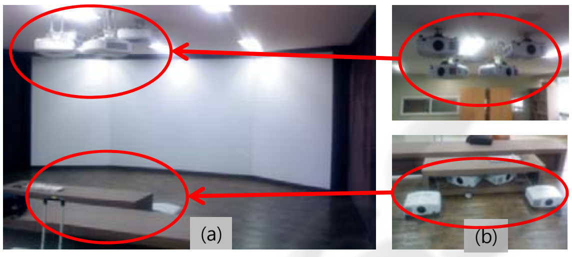

Figure 3: (a) Screen, (b) arrangement of projectors.

4 CALIBRATION

The graphic simulations were carried out by a program written in Visual C++ with direct X. As mentioned above, we used 8 projectors to create huge and high resolution images. Since projectors can be moved or rotated by a small amount of disturbance (for example, certain vibration, small impact, and/or etc.), we overlapped the portions which the projectors undertook as shown in Figure 4. However, this installation causes an image to distort. For compensating this distortion, we conducted geometric calibration.

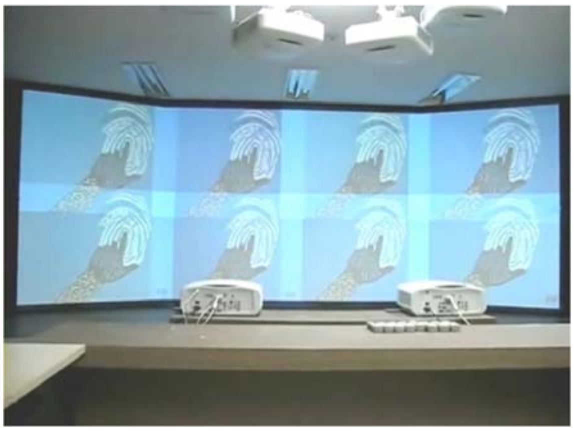

Figure 4: Overlapped Projection.

Figure 5 shows an example of geometric calibration procedure when four projectors employed in a tiled display. Figures 5(a) and 5(b) show the images before and after the geometric calibration, respectively. Consider the situation where four projection sub-images are overlapped and distorted according to the arrangement of projectors as shown in Figure 5(a). These overlapped and distorted sub-images need to be adjusted to the compensated region (bold rectangle portions (Figure 5(b)) through the calibration method.

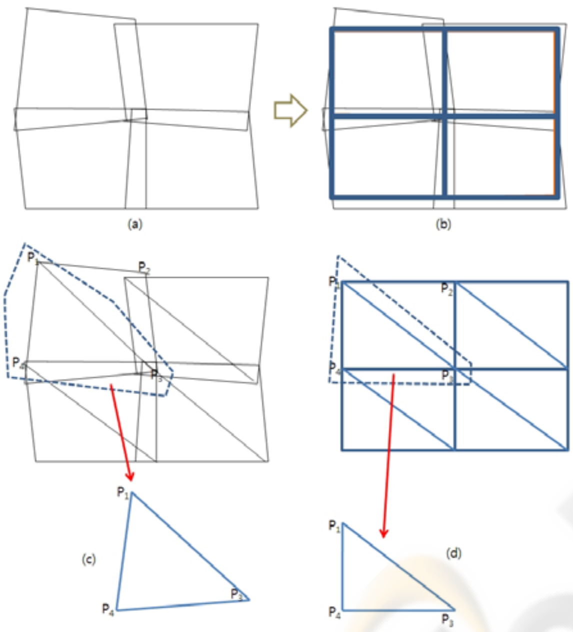

Figure 5: Geometric Calibration.

$P_1 = (x_1,y_1),\quad P_2 = (x_2,y_2),\quad P_3 = (x_3, y_3)$ (1.a)

$P'_1 = (s_1,t_1),\quad P'_2 = (s_2,t_2),\quad P'_3 = (s_3, t_3)$ (1.b)

$$M = \begin{bmatrix} m11 & m12 & m13 \\ m21 & m22 & m23 \\ 0 & 0 & 1 \end{bmatrix} = \begin{bmatrix} s1 & s2 & s3 \\ t1 & t2 & t3 \\ 0 & 0 & 1 \end{bmatrix} \times \begin{bmatrix} x1 & x2 & x3 \\ y1 & y2 & y3 \\ 0 & 0 & 1 \end{bmatrix}^{-1} \quad (1.c)$$

For compensation, original projection portions and the calibrated projection portions are divided into triangles, respectively as shown in Figures 5(c) and 5(d). After that we computed transformation matrix from the triangle 1 (P_1,P_3, P_4) to triangle 2 (P'_1,P'_3, P'_4) using equation 1. In Figures 5(c) and 5(d), let's define the coordinate values of P_1, P_3, P_4 as (x_1,y_1), (x_3,y_3), and (x_4,y_4), respectively. We also define the coordinate values of P'_1, P'_3, P'_4 as (s_1,t_1), (s_3,t_3), and (s_4,t_4), respectively. Figures 6(a) and 6(b) show the results before and after the calibration method, respectively.

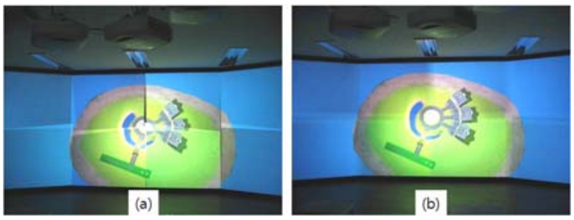

Figure 6: (a) before and (b) after calibration.

5 VIRTUAL ENVIRONMENT FOR EDUCATION

In the proposed tiled display system, we implemented a virtual silicon island (VSI) where users can learn semiconductor manufacturing processes. Users arrived at the VSI and walked in one of the buildings where they can study the semi-conductor manufacturing process.

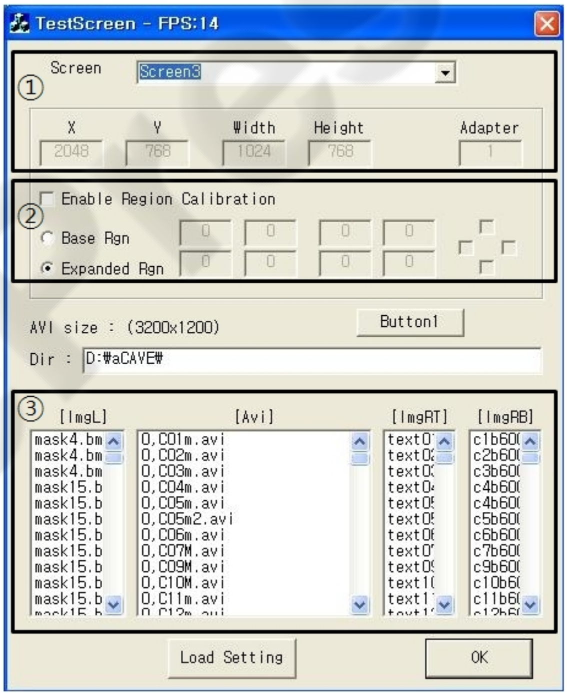

Figure 7: VSI authoring tool.

We developed a VSI authoring tool in order to easily create, edit, and play semiconductor contents. A user can insert or delete the semiconductor manufacturing components through the VSI authoring tool. As shown in Figure 7, the VSI authoring tool consists of a screen control part(①), a calibration part(②), and a contents control part(③). The screen control part allows a user to determine the size of images. The calibration part adjusts the overlapped and the projective regions. In the contents control part, multimedia objects based on movie clips are displayed. Once multimedia contents are registered in the contents control part, a user can control and play them on the huge screen by just clicking a mouse or pressing a keyboard. Figure 8 shows the semiconductor education contents based on the proposed tiled display system.

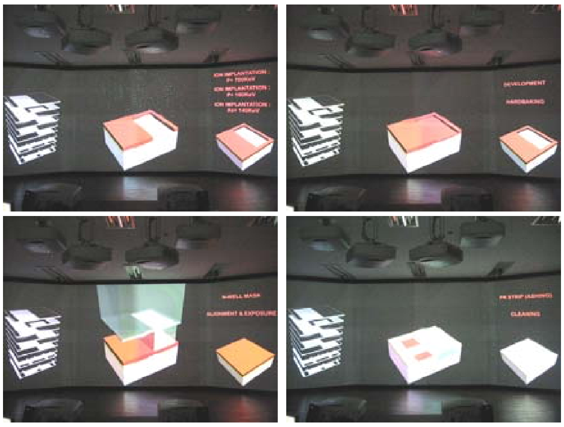

Figure 8: Semiconductor educational contents.

6 CONCLUSIONS

A virtual reality system provides the sense of reality and becomes a more user-friendly interface than the other systems. In this work, we developed the tiled display system for educating semiconductor manufacturing processes. Moreover, we conducted calibration in order to compensate the distorted image and to increase the sense of reality.

We are currently considering natural interaction for effective lecture with the proposed platform. Even though, the proposed system does not include natural interaction (for example, gesture recognition), it has the potential of an immersive education platform as an effective tutor.

ACKNOWLEDGEMENTS

This work was supported by VTRC (Virtual Training Research Center) in KUT (R-2008-0123). This work was also supported by the Korea Science and Engineering Foundation(KOSEF) grant funded by the Korea government(MOST) (R01-2007-000-20977-0).

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